PW1100G-JM

LINE AND BASE MAINTENANCE
Airbus A319/A320/A321

ABOUT THIS GUIDE

Subject Matter:
This training guide describes components and systems found on the PW1100G-JM geared turbofan. It also covers engine features and configuration; engine-related aircraft systems, and line maintenance tasks.

Intended For:
This document is designed for B1 Maintenance Technicians and other personnel associated with line and base maintenance. It provides a detailed description of system operation, component location, onboard reporting systems, and fault isolation procedures to aircraft maintenance manual level. Personnel attending this Level III training should possess the knowledge and experience required to maintain turbine powered transport aircraft.

Conformance to Simplified English:
This document follows the guidelines in the Aerospace and Defense Industries Association of Europe document *ASD Simplified Technical English Specification ASD-STE100.*™ Simplified English is designed to achieve directness, simplicity, and ease of vocabulary recognition.

Note that due to engine production schedules, some discrepancies may exist between actual production components and course content.

U.S. Export Classification:
EAR ECCN 9E991, Classification Request 2388072

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CHAPTER 1

POWER PLANT

ATA 71

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT	A Post Maintenance Test is required.
WARNING	Avoid injury by following guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Identify the purpose of the power plant.
2. Recognize power plant components.
3. Identify the purpose of the Drainage System.
4. Identify Line Replaceable Units (LRUs).

PW1100G-JM ENGINE OVERVIEW

The PW1100G-JM turbofan engine powers the Airbus New Engine Option (NEO) aircraft, including A319, A320, and A321 models. It is an axial flow, twin-spool turbofan engine with an ultra-high bypass ratio and low-speed, gear-driven fan. The engine includes core-mounted Angle and Main gearboxes and is mounted on a pylon that extends below and forward of the wing leading edge.

Advantages of the PW1100G-JM Engine

Conventional gas turbine engines restrict the low compressor and low turbine to less-than-optimal operating speeds so that fan speed can operate in a range most efficient for fan diameter.

In contrast, the geared technology of the PW1100G-JM allows the fan and low rotor to operate at independent, optimal speeds for peak efficiency. These improvements in performance reduce fuel consumption, environmental impact, and noise. At the same time, operating costs are drastically reduced.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

STAY CLEAR OF OBJECTS DURING HOIST OPERATIONS OR WHEN THE ENGINE/AIRCRAFT IS SUPPORTED BY TEMPORARY TRANSITION SUPPORTS. UNLESS SPECIFIED IN THE PROCEDURES, DO NOT WORK ON OBJECTS SUSPENDED OR SUPPORTED BY TEMPORARY TRANSITION SUPPORTS.

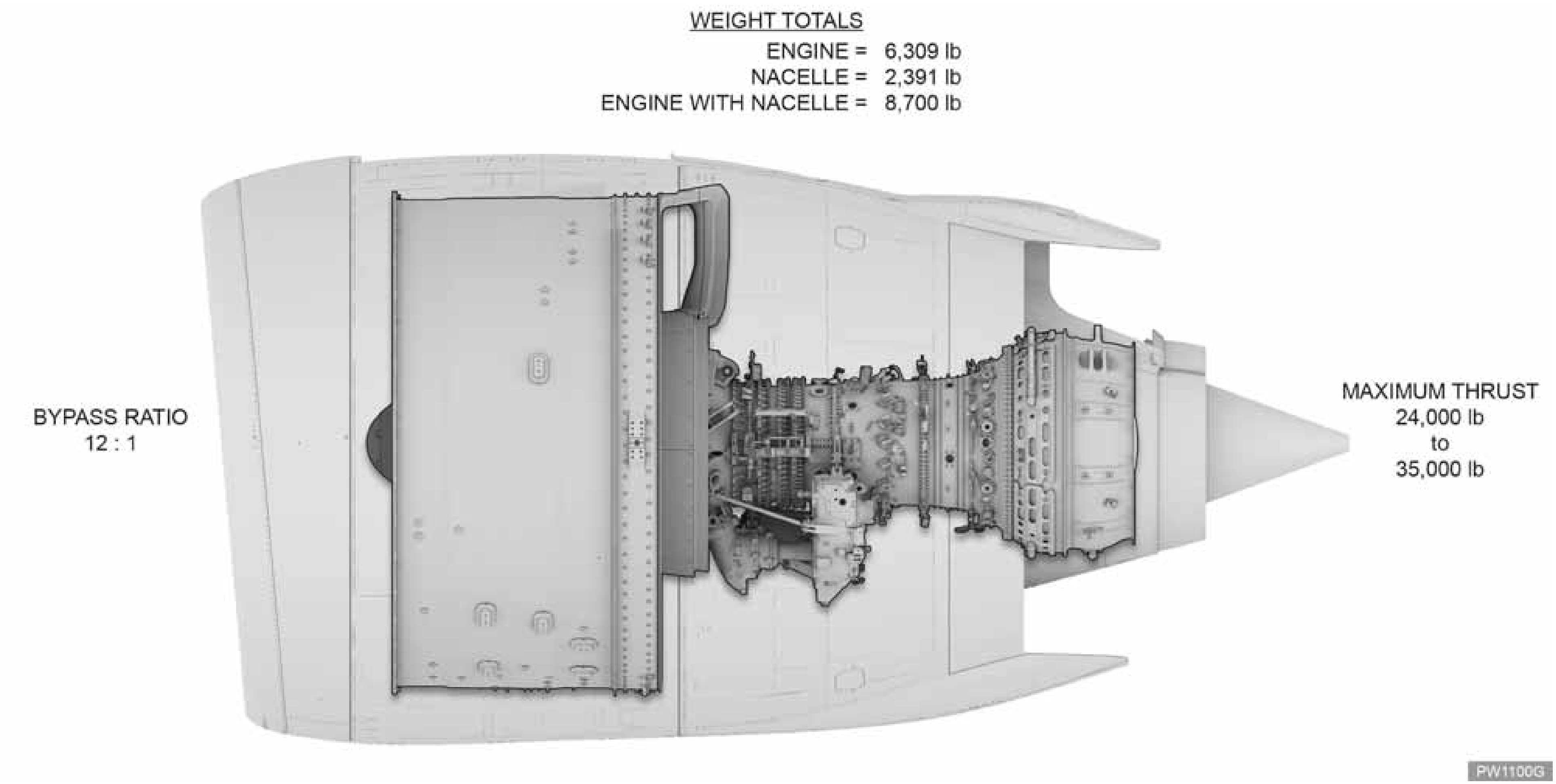
STAND CLEAR OF OBJECT BEING LIFTED. BE PREPARED FOR POTENTIAL UNBALANCE CONDITIONS DURING HOIST OPERATIONS. FAILURE TO COMPLY MAY RESULT IN DEATH OR INJURY TO PERSONNEL AND/OR DAMAGE TO AIRCRAFT OR EQUIPMENT.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER’S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

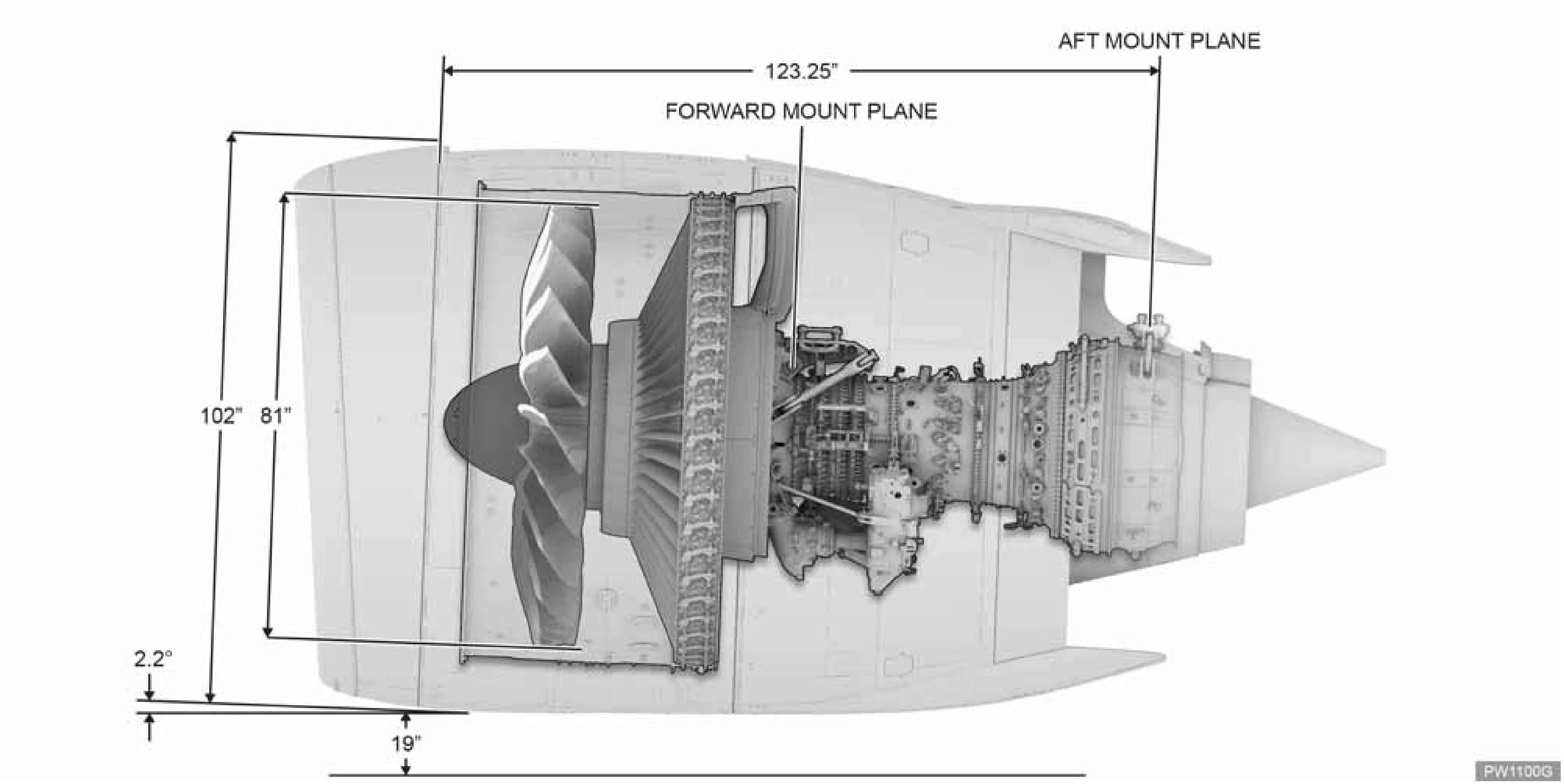
Aircraft and Engine Specifications		PW1100G Designation
Thrust		24,000–35,000 lb
Bypass ratio		12:1
Engine inlet diameter	Overall nacelle	102 in. (259 cm)
	Fan blade tip	81 in. (205.7 cm)
Engine weight	Engine with nacelle	8,700 lb (3946 kg)
	Engine only	6,309 lb (2862 kg)
Aircraft models		A319, A320, A321
Passenger capacity		124–235

Naming Convention		
PW	Pratt & Whitney	
1	Engine Model 1000	
1	Airbus airframe	
33	Thrust (lb x 1,000)	
G	Geared turbofan	GTF
J	Japanese Aero Engines Corporation	JAEC
M	MTU Aero Engines	

AIRBUS A320neo SPECIFICATIONS



ENGINE SPECIFICATIONS (1 OF 2)



ENGINE SPECIFICATIONS (2 OF 2)

POWER PLANT SYSTEMS OVERVIEW

The engine, also known as the *power plant,* supplies propulsive energy to the aircraft and provides electrical power and hydraulic pressure for aircraft systems. In addition it provides pressurized air for the aircraft Pneumatic System, which includes cabin pressurization, heating, and cooling.

The power plant includes the basic engine with its nacelle and its control components, which may include Buyer Furnished Equipment (BFE) and Engine Buildup Units (EBU) system components. BFE are components selected by the airframer that supply electrical and hydraulic power, and control pneumatics used by the aircraft. EBU are found in the Engine Mounts and Drainage systems. The engine with the BFE and EBU installed is called a *demountable power plant*.

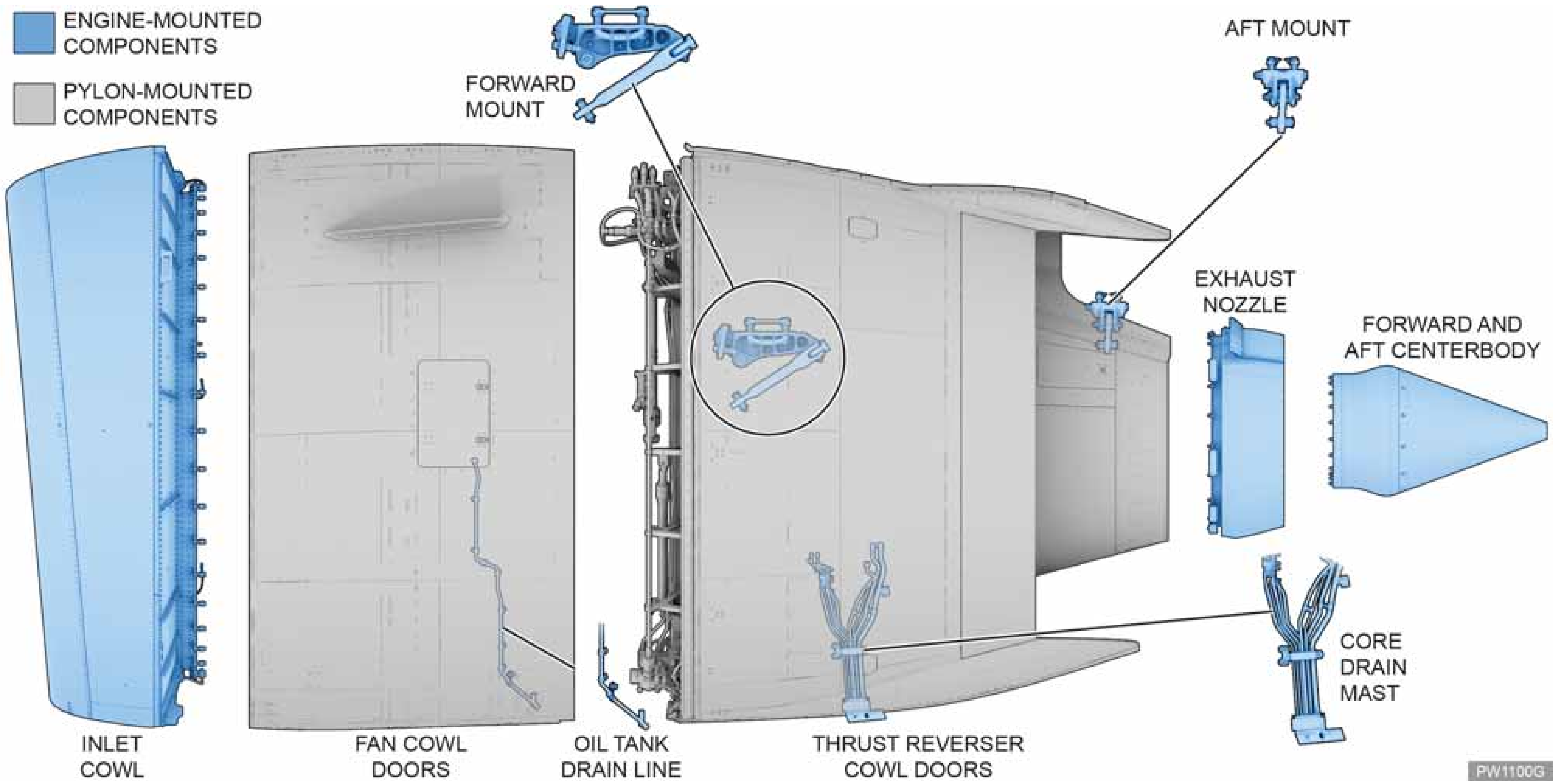
The engine is controlled by the Full Authority Digital Electronic Control (FADEC) system and is designed for safe and reliable operation.

Other power plant-related topics include:

- engine ground run danger zones
- preservation and replacement
- engine removal and installation.

Power plant subsystems and their components are listed in the table.

System	Type	Components
Nacelle	Pylon-mounted	• Fan cowl o Strakes • Thrust reverser cowl doors
	Engine-mounted	• Inlet cowl • Exhaust nozzle • Centerbody (exhaust plug)
Engine Mounts		• Forward mount • Aft mount • Thrust links
Drainage		• Engine drains • Core engine drains



POWER PLANT SUBSYSTEMS

NACELLE SYSTEM

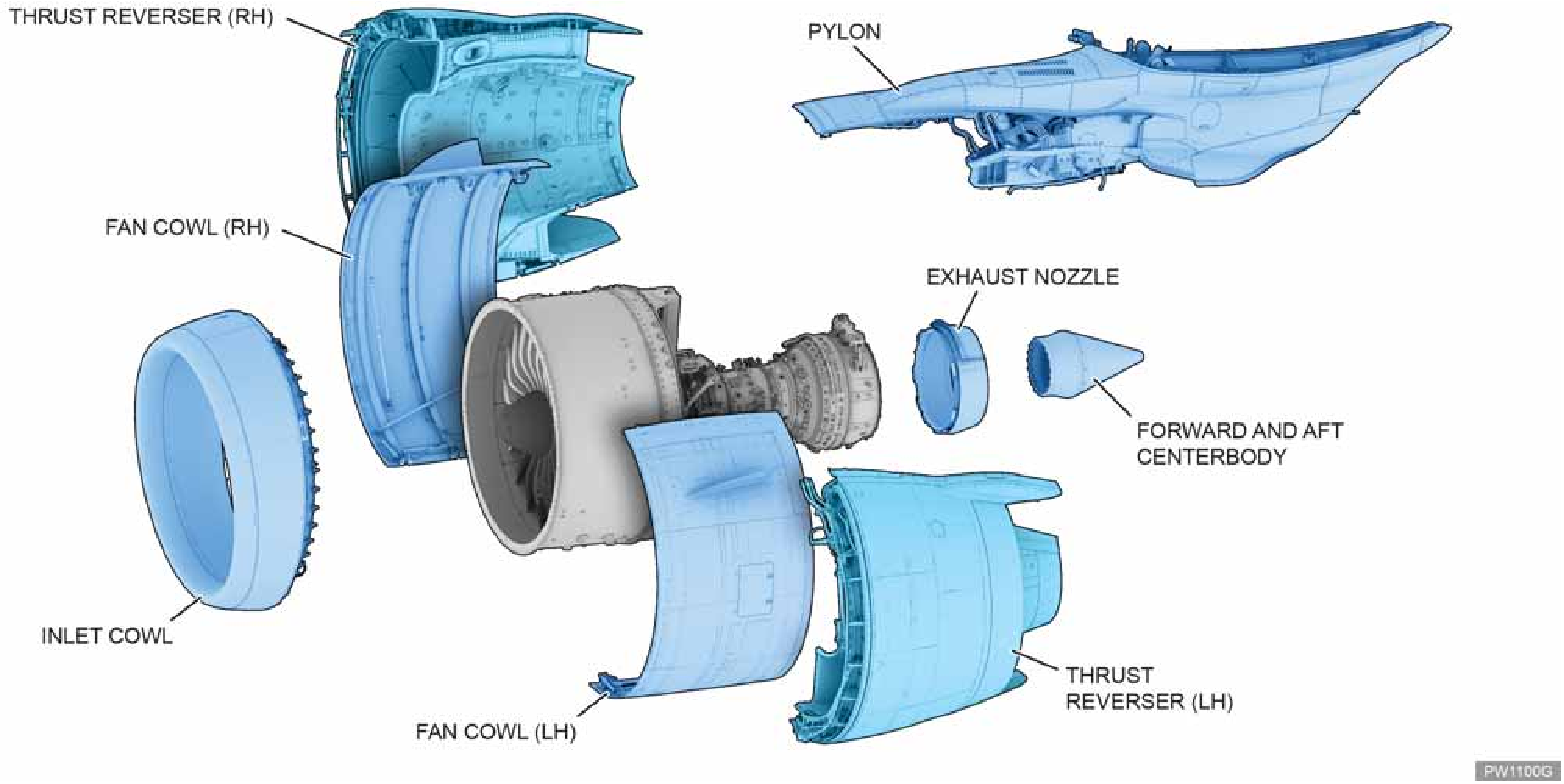
The engine nacelle provides an aerodynamic and protective enclosure for engine-mounted components.

The nacelle cowling controls airflow around and through the engine. Cowl doors give access to engine components for maintenance and servicing.

The nacelle includes a Thrust Reverser System as well as an Exhaust System with an exhaust nozzle and forward and aft centerbody (also known as the exhaust plug). The nacelle also includes the inlet and fan cowls.

Nacelle System components are mounted to the engine and to the pylon. They provide the engine with these capabilities:

- noise attenuation
- smooth airflow around the engine, which reduces drag
- protection of engine accessories
- access points for servicing and maintenance
- ventilation of the engine fan and core zones
- collection and discharge locations for oil, fuel, and hydraulic fluid from the engine and its components.



NACELLE SYSTEM COMPONENTS AND PYLON

NACELLE SYSTEM (Cont.)

Inlet Cowl

LRU

Purpose:

The inlet cowl's aerodynamic barrel smooths airflow, providing uniform pressure as air reaches the fan.

Location:

The inlet cowl is secured to the engine fan case Flange A by the aluminum inlet attach ring.

Description:

The cowl's outer skin provides even airflow across the engine nacelle. The inner skin forms the engine inlet and acoustic treatment. The inlet is interchangeable between engines.

The forward and aft bulkheads provide impact protection and structural support for the inlet assembly.

The outer barrel is a three-piece assembly extending from the inlet lip interface to the leading edge of the fan cowl.

Lightning strike protection is provided by an expanded copper screen layer impregnated into the outer barrel assembly.

Safety Conditions

WARNING

STAY AWAY FROM THE DANGER AREAS AT THE FRONT AND THE SIDES OF THE ENGINE DURING OPERATION. THE SUCTION IS SUFFICIENT AT THE AIR INTAKE COWL TO PULL A PERSON INTO (IN PART OR FULLY) THE ENGINE. THIS CAN KILL A PERSON OR CAUSE A BAD INJURY.

CAUTION

BEFORE YOU START THE ENGINE MAKE SURE THAT THERE ARE NO LOOSE OBJECTS IN THE AIR INTAKE COWL AND IN THE AREA NEAR THE AIR INTAKE. THE SUCTION IS SUFFICIENT AT THE AIR INTAKE COWL TO PULL LOOSE OBJECTS INTO THE ENGINE AND CAUSE MUCH ENGINE DAMAGE.

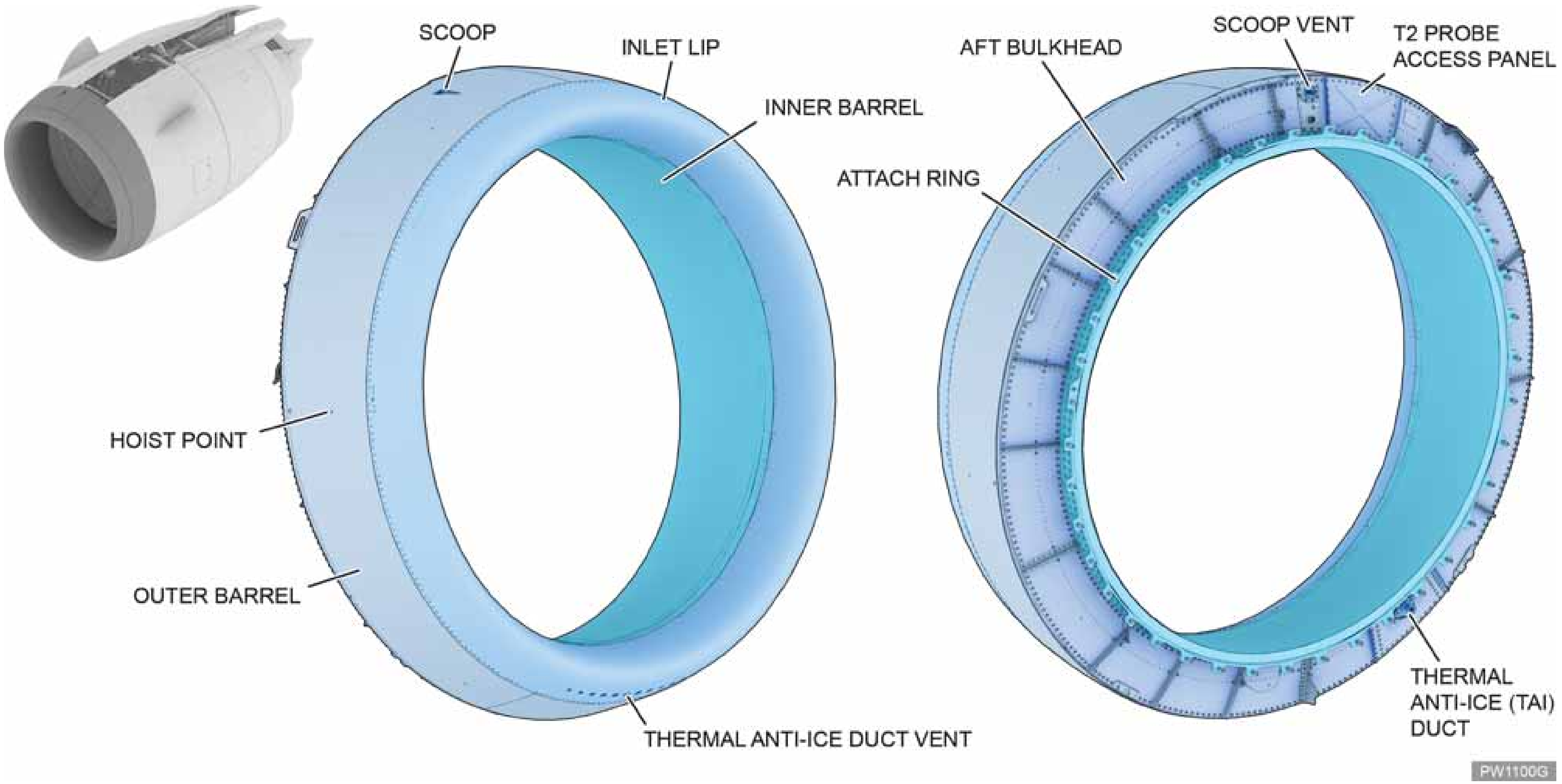
A panel in the outer barrel provides access for maintenance of the Thermal Anti-Ice (TAI) duct that supplies the inlet lip with hot air. Anti-ice air exits the TAI vent located at 6:00 on the inlet lip. Opening the right fan cowl on the aft bulkhead provides access to the anti-ice supply line.

A second panel serves as access to the T2 probe and the wiring harness, routed aft across the inner barrel to the aft bulkhead mounted interface.

A small, flush scoop vent located on the inlet outer barrel provides fan compartment cooling.

The inner barrel has gravity drainage holes embedded within the core.

The inlet incorporates a total of two hoist attachment points, one located on each side.



NACELLE SYSTEM – INLET COWL

NACELLE SYSTEM

Inlet Cowl (Cont.)

Safety Conditions

WARNING

WEAR APPLICABLE PERSONAL PROTECTIVE EQUIPMENT (PPE) WHEN YOU DO THIS TASK. BEFORE YOU USE PPE, READ, UNDERSTAND AND OBEY ALL INSTRUCTIONS FOR ITS USE. THESE INSTRUCTIONS INCLUDE INSTRUCTIONS FROM THE MANUFACTURER, YOUR EMPLOYER AND GOVERNMENT REGULATIONS. YOU CAN GET INJURED IF YOU DO NOT USE PPE. GET INSTRUCTIONS FROM YOUR EMPLOYER ON WHICH PPE IS NECESSARY.

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE CAN STAY HOT FOR ALONG TIME. IF YOU DO NT OBEY THIS INDSTRUCTION, INJURY CAN OCCUR.

BE CAREFUL WHEN YOU USE COMSUMABLE MATERIALS. OBEY THE MATERIAL MANUFACTURER'S INSTRUCTONS AND YOUR LOCAL REGULATIONS.

MAKE SURE THAT THE INLET COWL IS SUFFICIENTLY HELD DURING REMOVELA/INSTALLATION. THE INLET COWL WEIGHS APPROXIMATELY THAN 300 LB (136 KG). IF YOU DO NOT DO THIS, INJURY TO PERSONNEL AND/OR DAMAGE TO COMPONENTS CAN OCCUR.

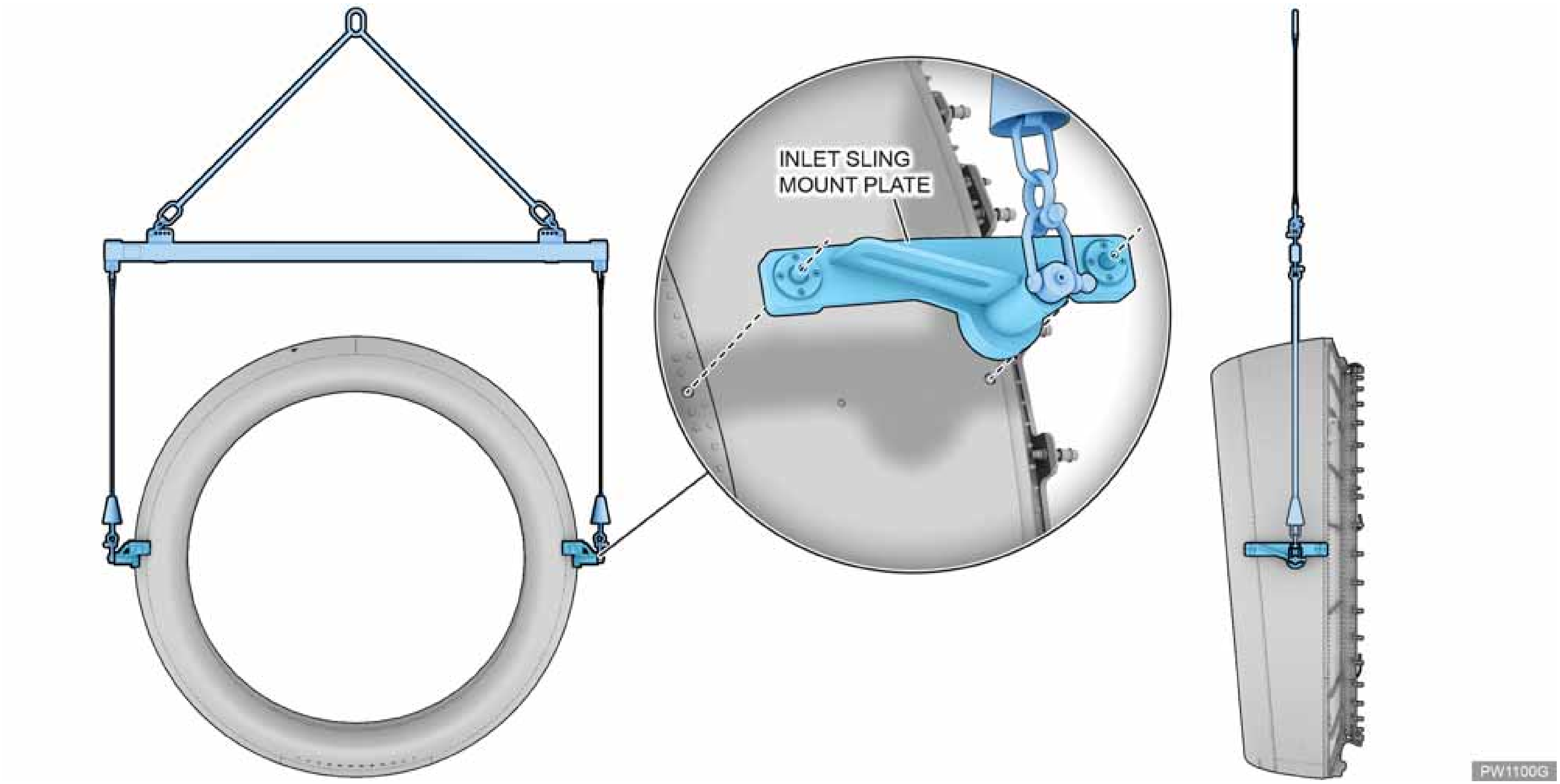
Safety Conditions

CAUTION

DO NOT TORQUE THE NUTS MORE THAN THE HIGHER TORQUE LIMIT. IF YOU DO, DAMAGE TO THE FASTENERRTS CAN OCCUR.

WIPE CLEAN ALL PARTS AND TOOLS AS NECESSARY TO REMOVE UNWANTED DEBRIS AND PREVENT DAMAGE TO THE ENGINE.

BE CAREFUL NOT TO HIT OR RUB THE ANTI−ICE DUCT WHEN YOU REMOVE/INSTALL THE INLET COWL FROM THE ENGINE CASE. THE INLET COWL IS HEAVY AND CAN EASILY CAUSE DAMAGE TO THE ANTI-ICE DUCT.



NACELLE SYSTEM – INLET COWL HOIST

NACELLE SYSTEM (Cont.)

Fan Cowl

LRU

Purpose:

The fan cowl provides aerodynamic smoothness and a protective enclosure for the engine fan case and accessories. Fan cowl doors provide maintenance access to components and systems shown below.

• Anti-ice temperature and pressure sensors	
• Electronic Engine Control	EEC
• Prognostics and Health Management Unit	PHMU
• Pylon disconnects	
• Ignition exciter box	
• Engine Driven Pump (EDP) case drain filter	
• Oil tank	
• Thrust reverser torque box	
• Thrust Reverser Actuation System	TRAS
• Thrust Reverser Door Opening System	DOS

Location:

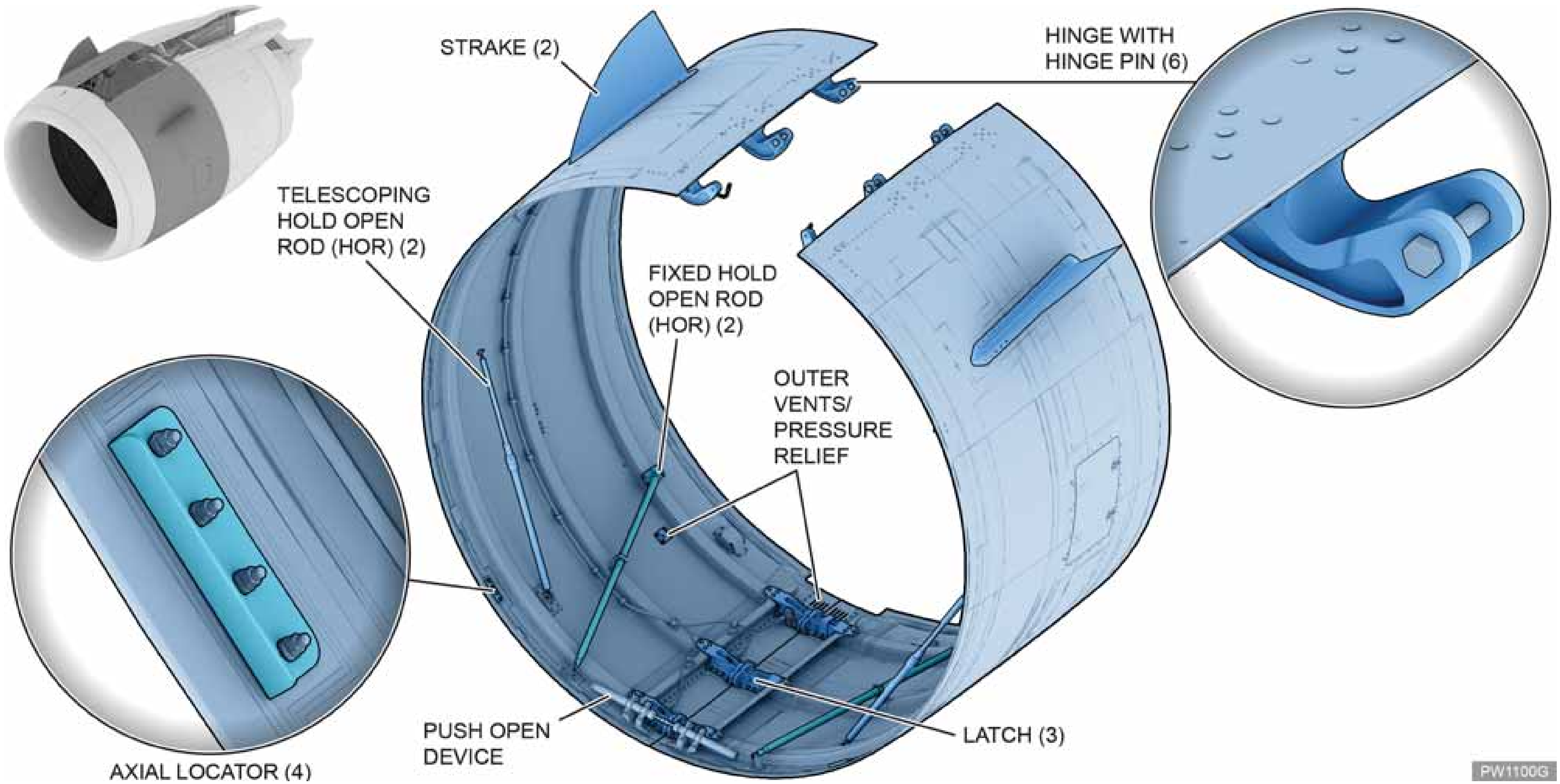
The fan cowl is pylon-mounted and covers the engine fan cases. It is positioned between the inlet and reverser cowls.

Description:

Fan cowl doors are one-piece structures. Two fan cowl axial locators per door align the cowls as they close. A copper mesh is embedded in the fan cowl laminate for lightning strike protection. Cowl doors are manually opened, and are held open with forward and aft Hold Open Rods (HOR).

The fan cowl is secured to the pylon above the engine by pins installed through the cowl door hinges and pylon fittings. The fan cowls are also secured beneath the engine by three tension latches. Visual indicators on the latch handles show when the latches have not been properly secured. A proximity sensor on each latch indicates when latches are not properly secured. A push open device near the forward latch assists in opening the fan cowls.

Two aerodynamic strakes deflect airflow as required in certain maneuvers related to aircraft performance. The strakes are mounted to the fan cowl outer surface on the inboard and outboard side.



NACELLE SYSTEM – FAN COWL (1 OF 2)

NACELLE SYSTEM

Fan Cowl (Cont.)

Safety Conditions

WARNING

THE FAN COWL DOOR WEIGHS APPROXIMATELY 123.9 LB (56.20 KG). MAKE SURE YOU DO NOT CAUSE DAMAGE TO THE FAN COWL DOOR OR THE PYLON WHEN YOU POSITION THE FAN COWL DOOR ADJACENT TO THE PLYON HINGES. IF YOU DO NOT DO THIS, INJURY TO PERSONNEL AND/OR DAMAGE TO THE COMPONENTS CAN OCCUR.

DO NOT OPEN THE FAN COWL DOORS WHEN WIND SPEEDS ARE MORE THAN 46 MPH (40 KNOTS). IF THE WIND MOVES THE FAN COWL DOOR, INJURY OR DAMAGE TO THE ENGINE CAN OCCUR.

BE CAREFUL IF YOU OPEN A FAN COWL DOOR WHEN THE WIND SPEED IS 28.77 MPH (25.1 KNOTS) OR MORE. IF THE WIND MOVES THE FAN COWL DOOR, INJURY AND/OR DAMAGE TO THE ENGINE CAN OCCUR.

MAKE SURE THE QUICK RELEASE PINS ARE LOCKED INTO PLACE AND INSTALLED CORRECTLY BEFORE YOU LOWER THE FAN COWL DOOR (2 OR 3). THE FAN COWL DOOR WEIGHS MORE THAN 75 LB (34 KG). INJURY AND/OR DAMAGE TO THE ENGINE CAN OCCUR IF THE DOOR FALLS.

MAKE SURE THE LANDING GEAR GROUND SAFETIES AND THE WHEEL CHOCKS ARE IN POSITION. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

Safety Conditions

WARNING

MAKE SURE THE AREA AROUND THE FAN COWL(S) IS CLEAR BEFORE THE FAN COWL(S) ARE OPENED. THE COWLS CAN GET DAMAGED IF THEY HIT AN OBJECT.

CAUTION

DO NOT USE MORE THAN 50 LBF (22.7 KGF) TO PUSH THE LATCH HANDLE CLOSED. EXCESS LOAD ABOVE THE STATED VALUE COULD CAUSE DAMAGE TO THE FAN COWL STRUCTURE.

MAKE SURE YOU INSTALL THE INLET COWL AND CLOSE THE THRUST REVERSER DOORS BEFORE YOU INSTALL THE FAN COWL DOORS.

MAKE SURE YOU DO NOT DAMAGE THE FAN COWL DOOR OR PYLON IF YOU LIFT THE FAN COWL DOOR MORE THAN 53 DEGREES FROM THE VERTICAL.

NACELLE SYSTEM

Fan Cowl

Description (Cont.)

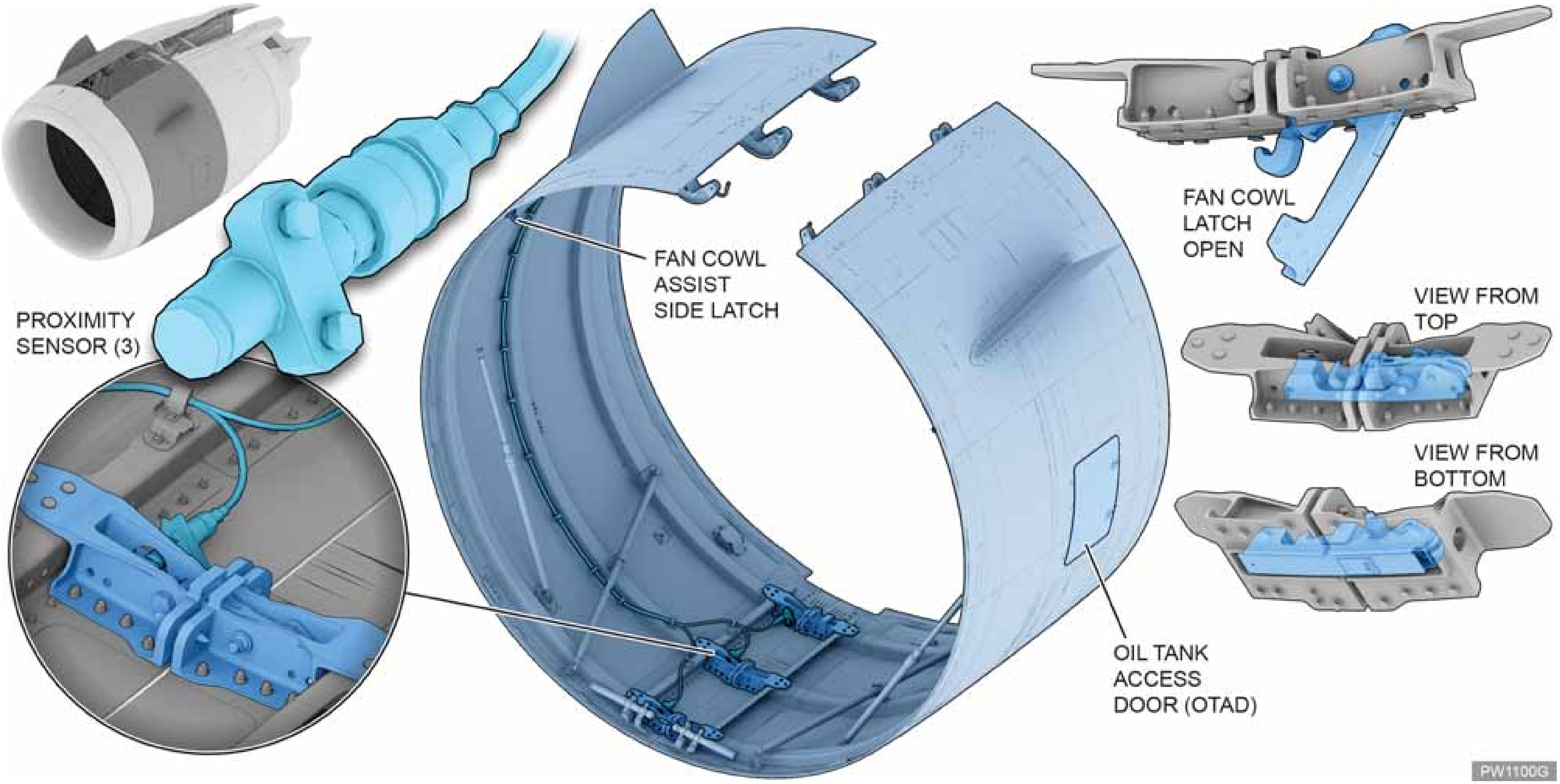
An outlet vent provides overpressure protection in the event of a burst anti-ice duct. Drain holes at the bottom of the fan cowls provide fluid drainage.

Each door has three hoist provisions used for removal and installation.

A fan cowl assist side latch secures the right-hand side fan cowl half to the inlet cowl. The side latch facilitates fan cowl closing by one person only.

The Oil Tank Access Door (OTAD) provides quick access to the oil tank, allowing oil service without opening the cowling. The OTAD is hinged at the front edge and secured with two latches that provide redundancy at the aft edge of the panel.

Each of three fan cowl door latches has a fan cowl door proximity sensor to alert the cabin crew to the fan cowls' position. Each sensor is able to detect whether the relative latch is locked, to avoid any fan cowl door loss in flight. In the event of sensor failure, the aircraft may still be dispatched per the MMEL provided that the latches are visually checked.



NACELLE SYSTEM – FAN COWL (2 OF 2)

NACELLE SYSTEM (Cont.)

Strakes

LRU

Purpose:

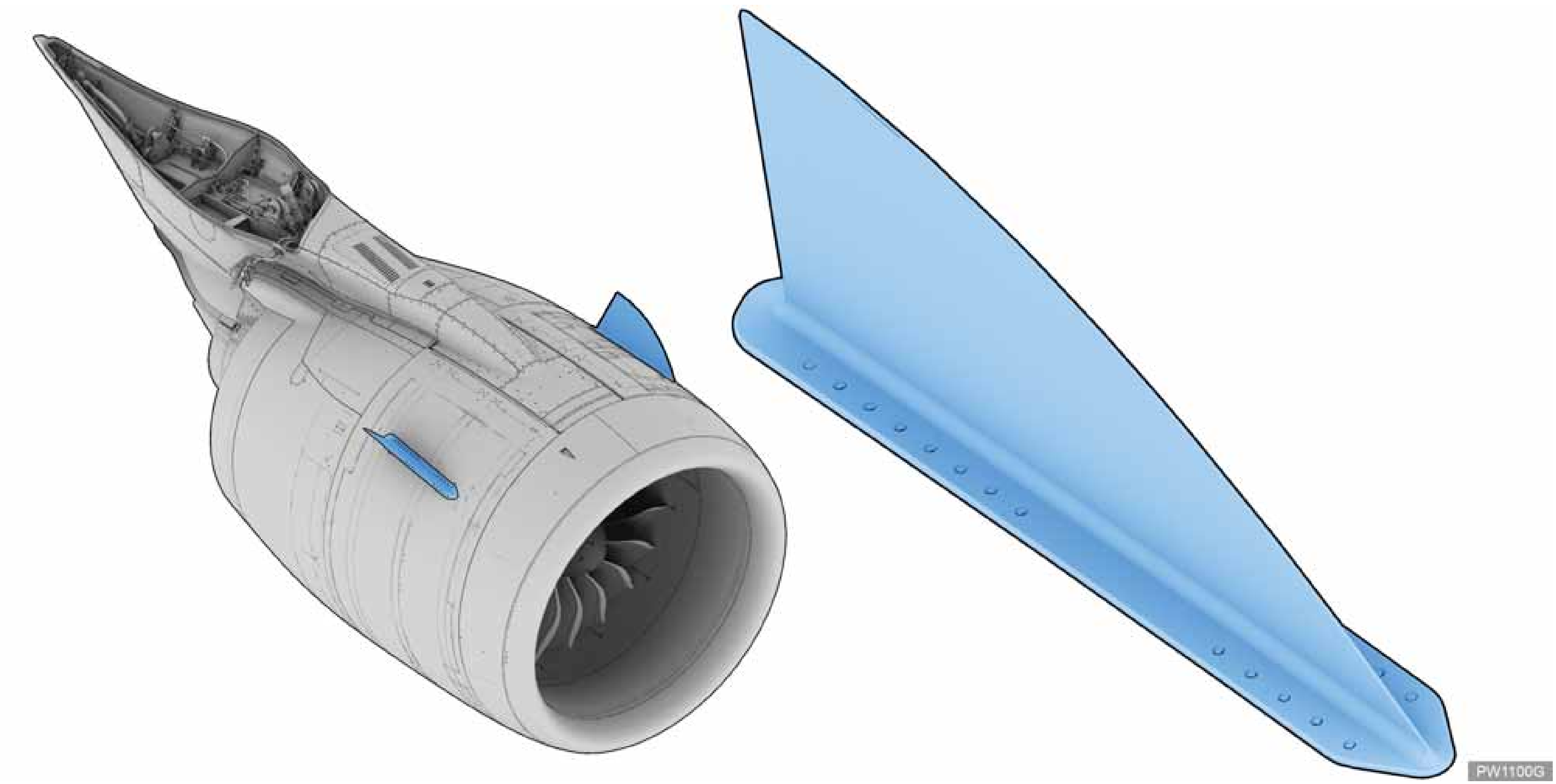
Strakes mounted to the fan cowl outer surface improve flight characteristics by decreasing the turbulence of airflow between the fan cowl door assembly and the wing leading edge.

Location:

Strakes are mounted to both the left and right fan cowl doors.

Description:

Strakes are attached to the inboard and outboard fan cowl door by 14 fasteners engaged into floating nut plates, located on the fan cowl interior skin.



NACELLE SYSTEM – STRAKES

NACELLE SYSTEM (Cont.)

Thrust Reverser Cowl Doors

Purpose:

The thrust reverser cowl doors form the duct for bypass airflow, protect the core, and house a Thrust Reverser System to slow the aircraft upon landing.

The thrust reverser cowl doors also facilitate core component maintenance.

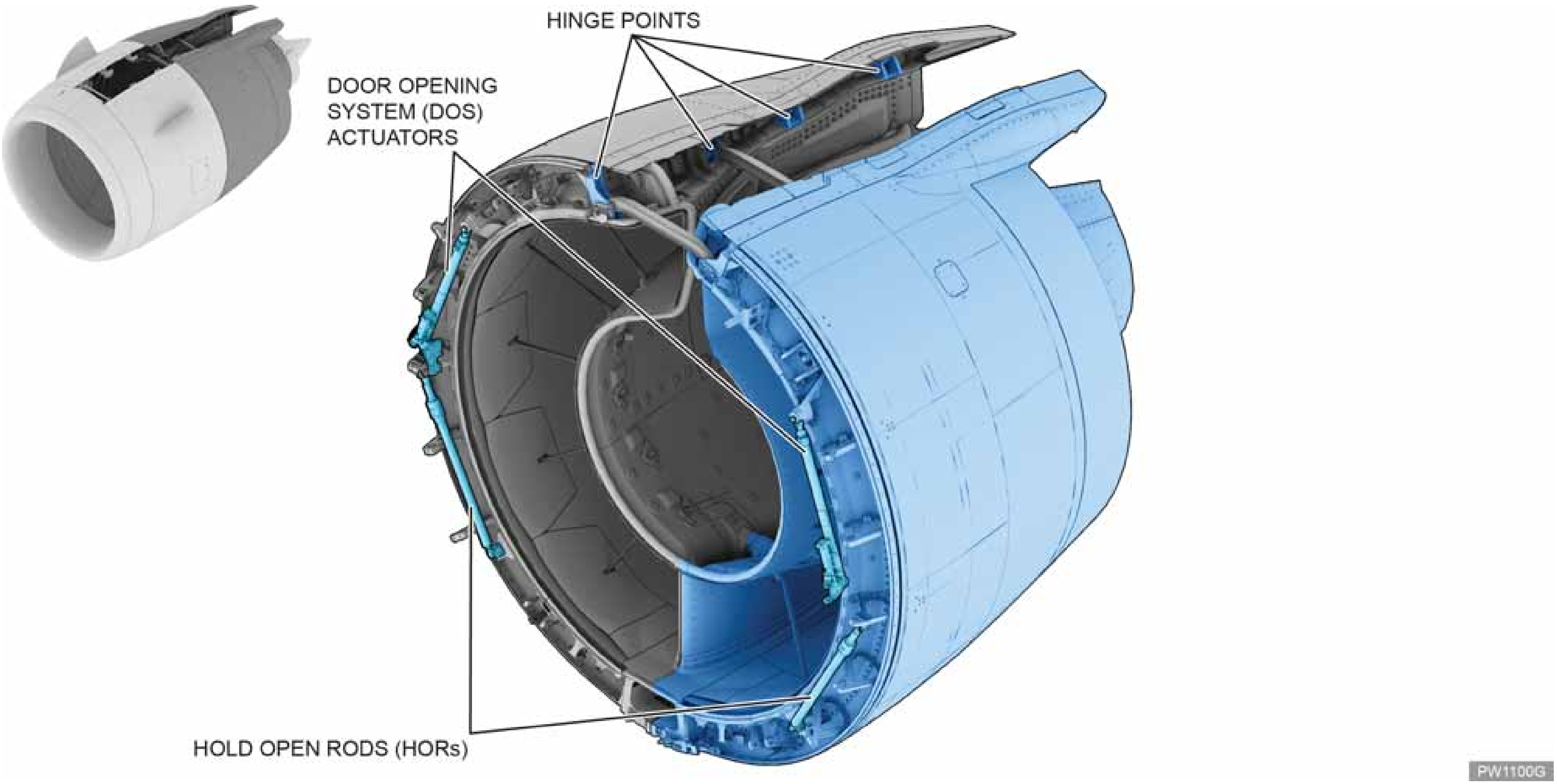
Location:

The halves hinge at the pylon, latching together along the bottom split line.

Description:

Thrust reverser cowl doors are composed of two mechanically independent halves. The cowl doors are sometimes referred to as the “C-duct” due to their shape.

They can be opened using the Door Opening System (DOS) by means of a hydraulic hand pump. Each door is equipped with a Hold Open Rod (HOR).



NACELLE SYSTEM – THRUST REVERSER COWL DOORS

ENGINE MOUNTS SYSTEM

Engine mounts transfer engine loads to the pylon. They are designed for thrust and aerodynamic loads and for inertial loads from aircraft maneuvers.

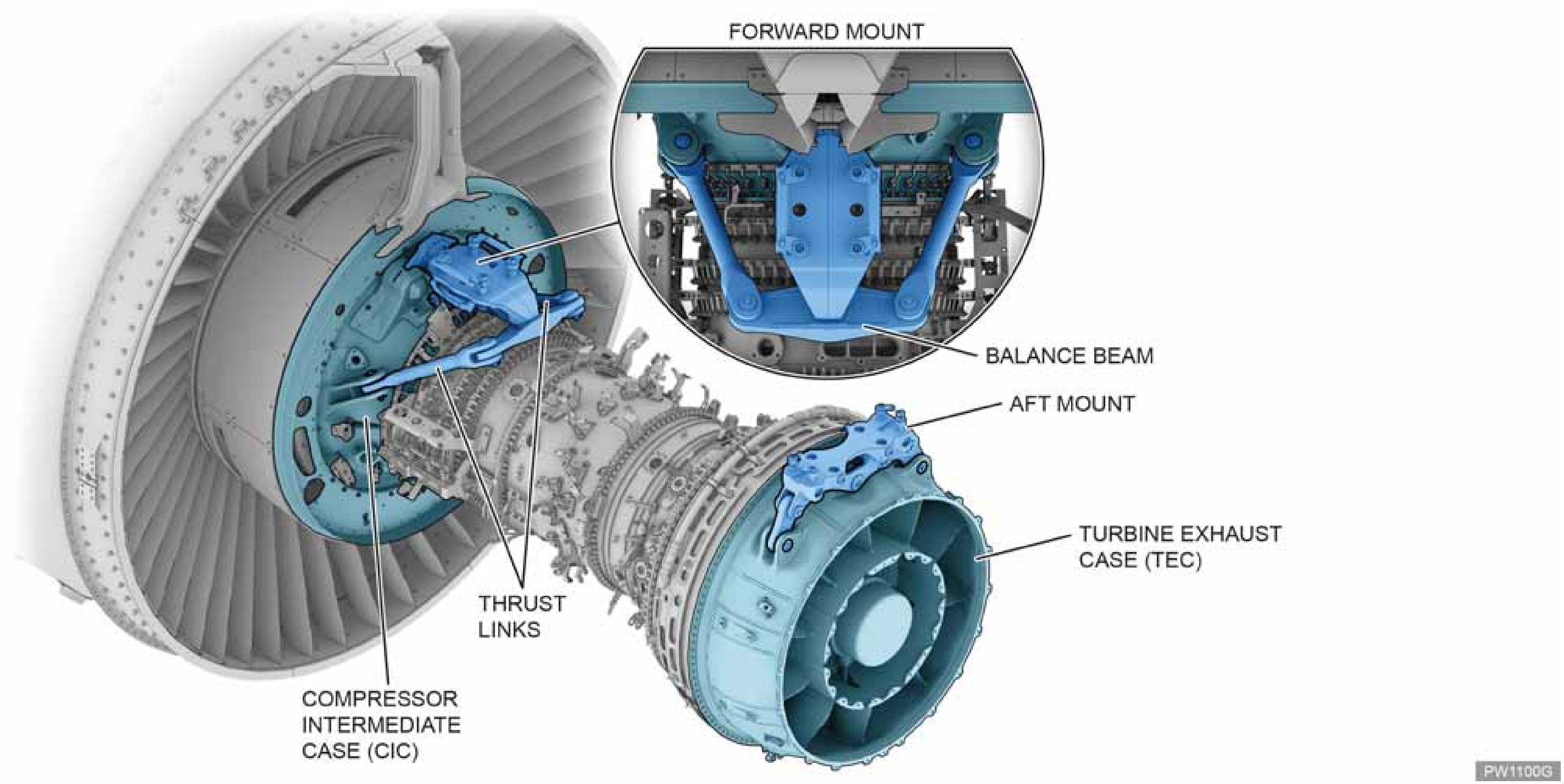
Mount assemblies have these functions:

- support the weight of the engine
- prevent the engine from turning around its axis
- hold lateral loads.

The Engine Mounts System comprises both a forward mount and aft mount subsystem.

The forward mount assembly is connected at the top of the engine's Compressor Intermediate Case. The aft mount assembly is connected at the top of the engine's Turbine Exhaust Case, which supports the rear of the engine.

The thrust link subassembly is connected to the Compressor Intermediate Case at approximately 9:30 and at 2:30 and to the forward mount through a balance beam.



ENGINE MOUNTS SYSTEM

ENGINE MOUNTS SYSTEM (Cont.)

Forward Mount Assembly

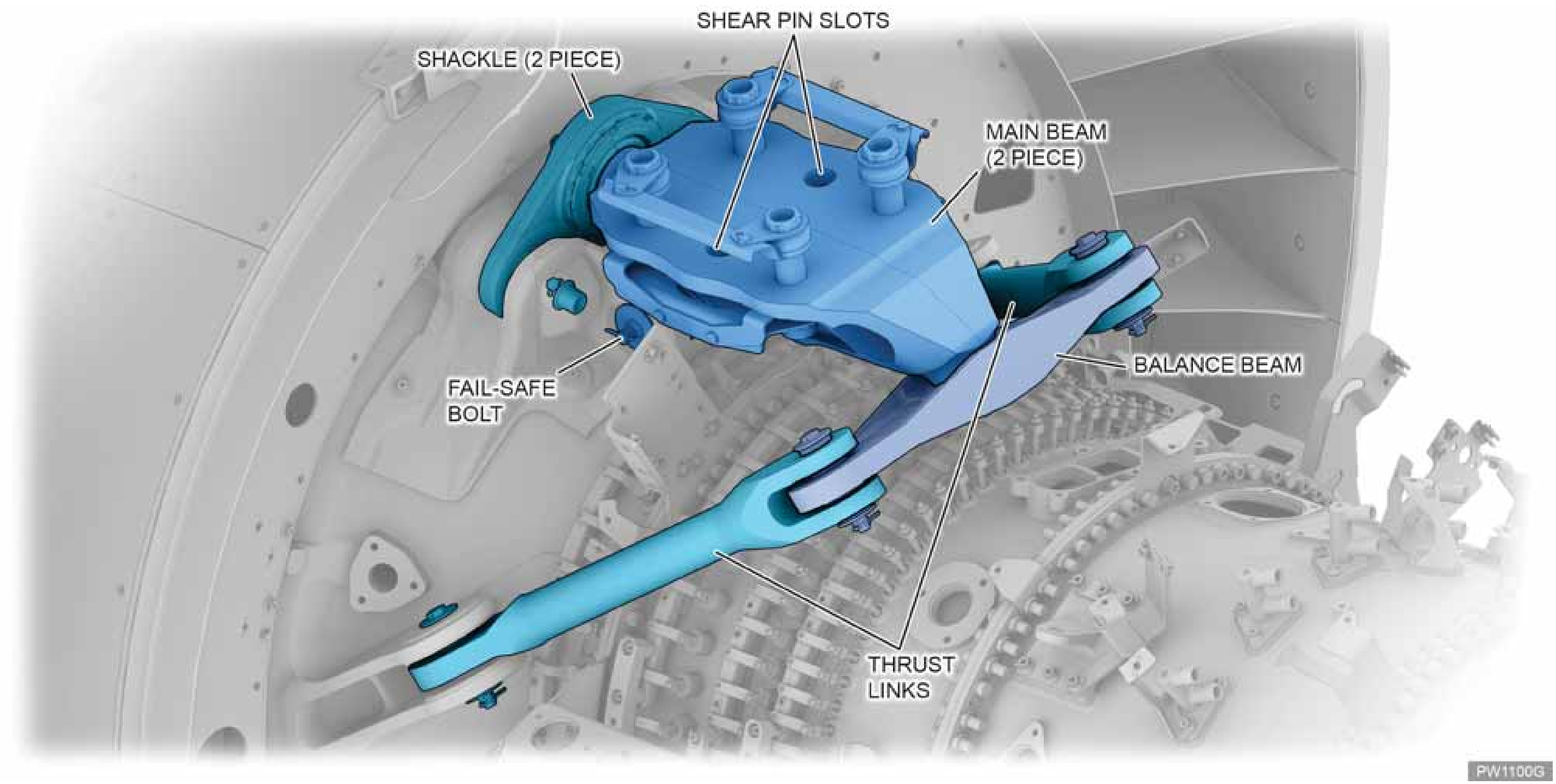
The forward mount assembly is attached to the Compressor Intermediate Case (CIC), and is connected to the pylon. The forward mount supports side and vertical loads using a two-link arrangement with bolts loaded in shear. A fail-safe bolt in the center of the mount provides a replacement load path if one of the thrust links fail. Main features of the forward mount assembly are below.

- Main beam
- Thrust links (2)
- Shear pin slots (2)
- Fail-safe bolt

The side and vertical loads at the forward mount couple with the aft mount loads to support overall engine pitch and yaw. Thrust links provide the primary load paths from the CIC to the pylon.

The forward mount is attached to the pylon with four bolts and two shear pins, which transmit vertical and shear loads into the pylon. The mount bolts use captive barrel nuts to ease removal.

The links are attached to the CIC and balance beam with shoulder bolts, self-locking nuts, and cotter pins.



ENGINE MOUNTS SYSTEM – FORWARD MOUNT ASSEMBLY

ENGINE MOUNTS SYSTEM (Cont.)

Aft Mount Assembly

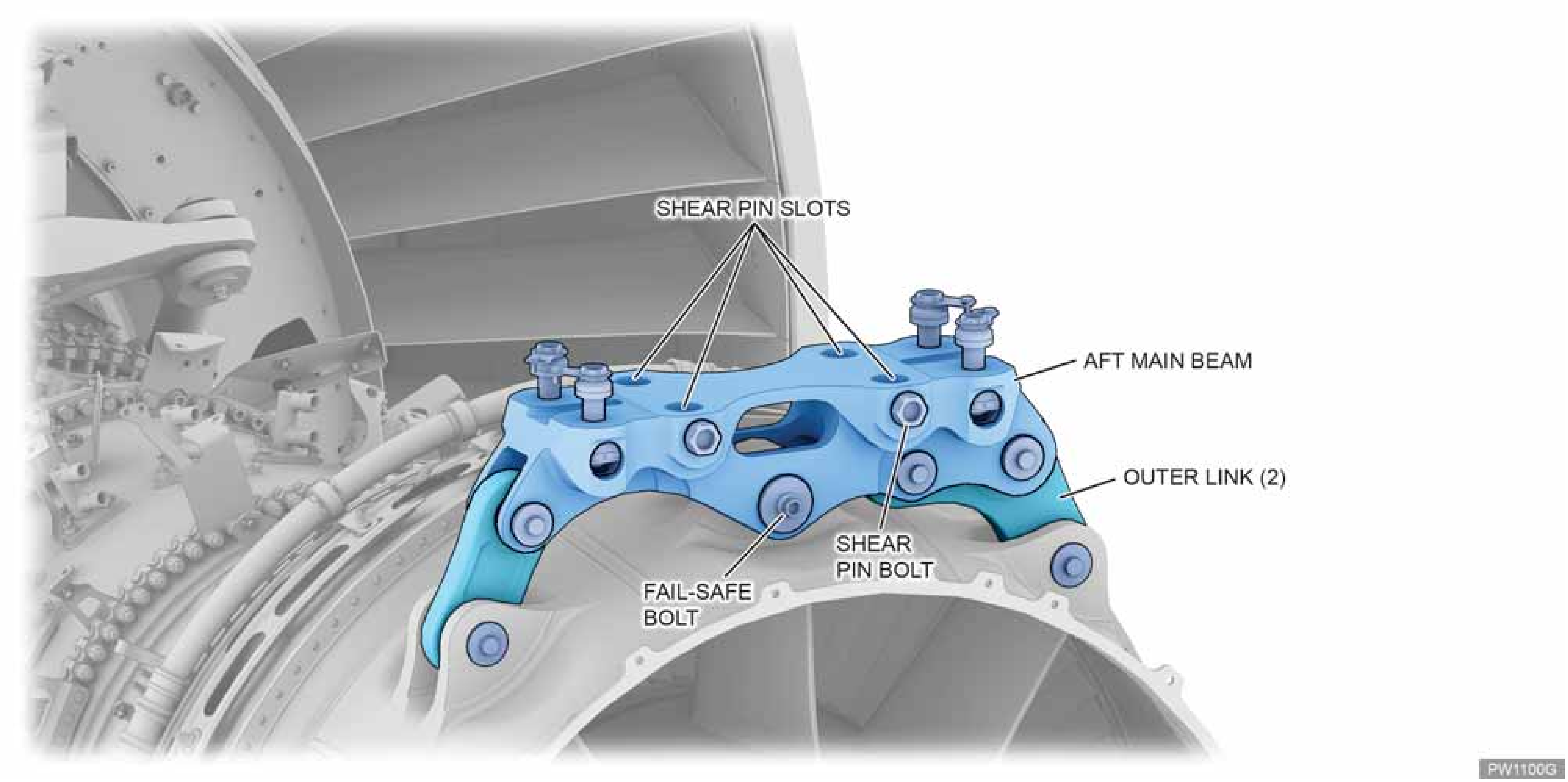
The aft mount is attached to the Turbine Exhaust Case (TEC) and reacts to engine fore-aft, side, vertical, and roll loads.

Main components of the aft mount assembly are below.

- Main beam
- Outer links (2)
- Shear pin slots (4)
- Fail-safe bolt

The assembly consists of a main beam attached to the Turbine Exhaust Case (TEC) with two outer links. There is a fail-safe pin in the center link on the main beam.

The two outer links are assembled to the beam with shear bolts. Each outer link is attached to the TEC with one shear bolt. The center link is attached directly to the TEC with another shear bolt. The failure of any one link on the aft mount will cause the system to transfer loads to a secondary load path.



ENGINE MOUNTS SYSTEM – AFT MOUNT ASSEMBLY

DRAINAGE SYSTEM

Engine Drains

LRU

Engine drains are one component of the larger Drainage System. Drains collect and discharge oil, fuel, and hydraulic fluid from the engine and pylon. Residual fluids are delivered to the lower bifurcation drain mast through dedicated drain tubes.

Drain components are located on the left and right sides, and at the bottom of the engine.

The wet bay is a cavity in the pylon where fluid connections are made. It includes a drain to take away any fluid leaked from those connections.

The system relies on gravity to transport the fluids to the drains. Drain tubes are supplied for the components listed in the chart.

The Main Gearbox (MGB) breather vent discharges breather air from the MGB and discharges oil from the oil tank scupper drain tube, the No. 4 bearing scupper, and the deoiler. The oil tank scupper drain and No. 4 Bearing scupper drain tubes converge with the breather vent and drain oil overboard.

The thrust reverser and fan cowl assemblies have drain holes to provide secondary drainage. If a drain tube cracks or a blockage causes fluid leakage in the fan and core compartments, this fluid will be expelled overboard via drain holes.

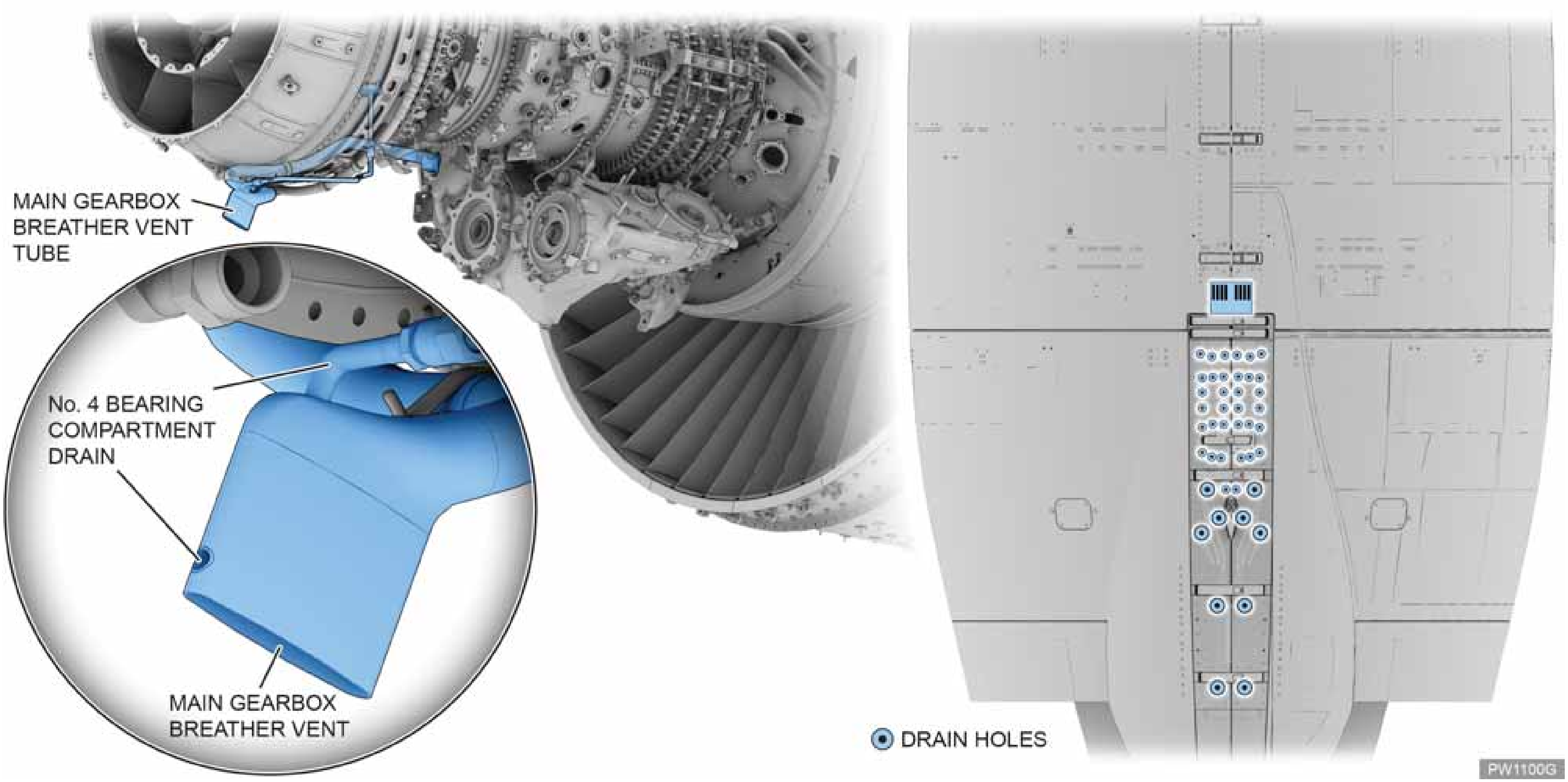
The IFPC drains through the fuel manifold drain port.

Related components from each of eight outlets are identified on the pylon tube at the drain mast.

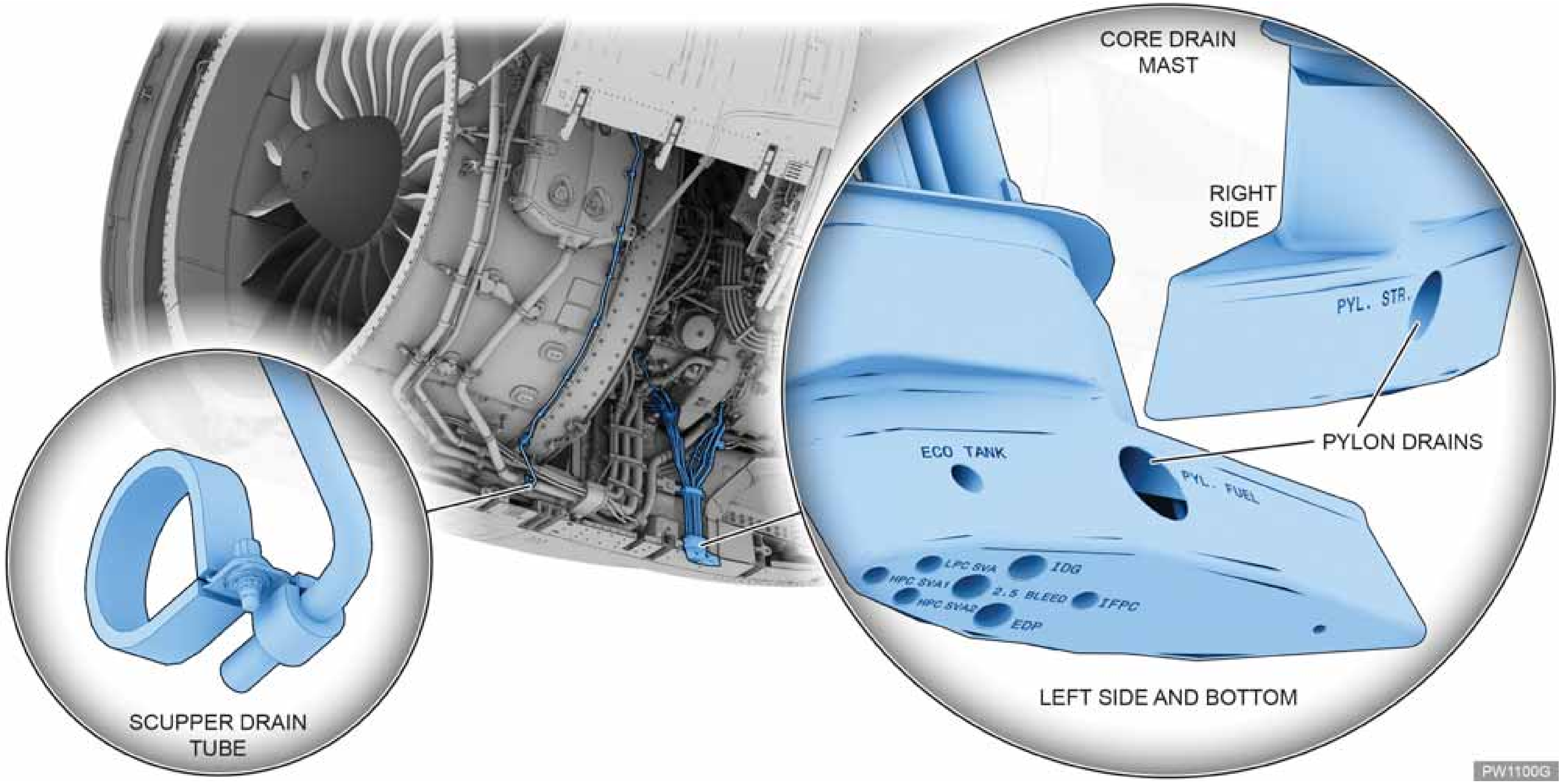
Drain mast areas and components are listed on the next page.

Drain Area	Component	
Fan Case	• Oil tank scupper	
Engine Core	• 2.5 Bleed Valve Actuator o LPC double wall oil lines	BVA
	• HPC primary and secondary Stator Vane Actuators	HPC SVA
	• LPC Stator Vane Actuator	LPC SVA
	• Integrated Drive Generator	IDG
	• Integrated Fuel Pump and Control	IFPC
	• Hydraulic Engine Driven Pump	EDP
	• Fuel recovery tank (“Ecology tank”)	
	• Pylon wet bay	
Main Gearbox Breather Vent Tube	• No. 4 Bearing scupper	
	• Deoiler	

DRAIN MAST AREAS AND COMPONENTS



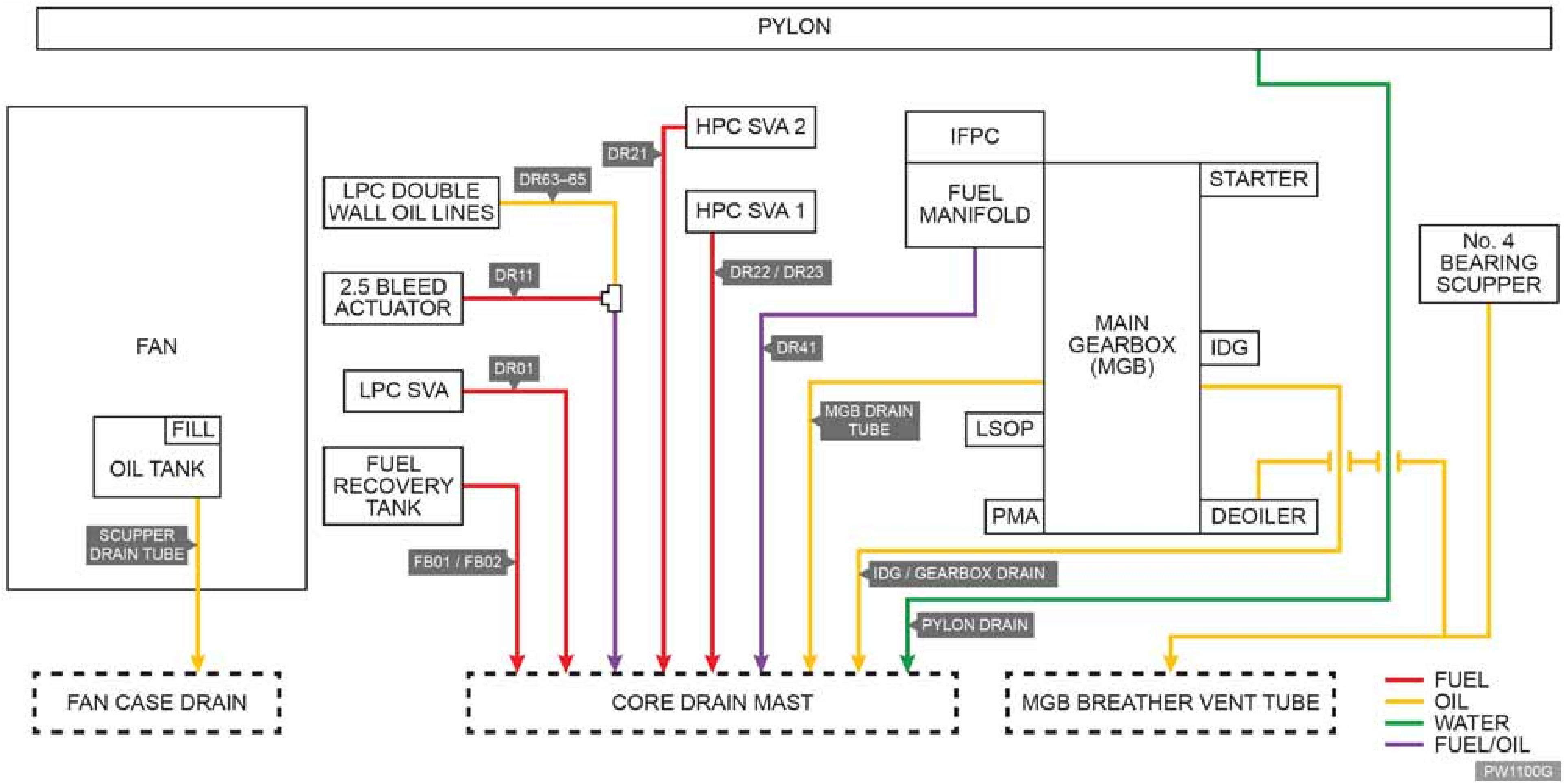
DRAINAGE SYSTEM – ENGINE DRAINS



DRAINAGE SYSTEM – ENGINE DRAINS

Fluid	Drain Location	Leakage Limit	
		CC/Hour	Drops/Min.
Oil	LPC 2.5 bleed cavity	None permitted	None permitted
	IFPC carbon seal	10	3.3
	Hydraulic pump carbon seal		
	IDG carbon seal		
Fuel	2.5 bleed actuator	15	5
	LPC Stator Vane Actuator		
	HPC Primary Stator Vane Actuator		
	HPC Secondary Stator Vane Actuator		
	IFPC seal	2	1

DRAINAGE SYSTEM – DRAIN MAST LEAKAGE LIMITS

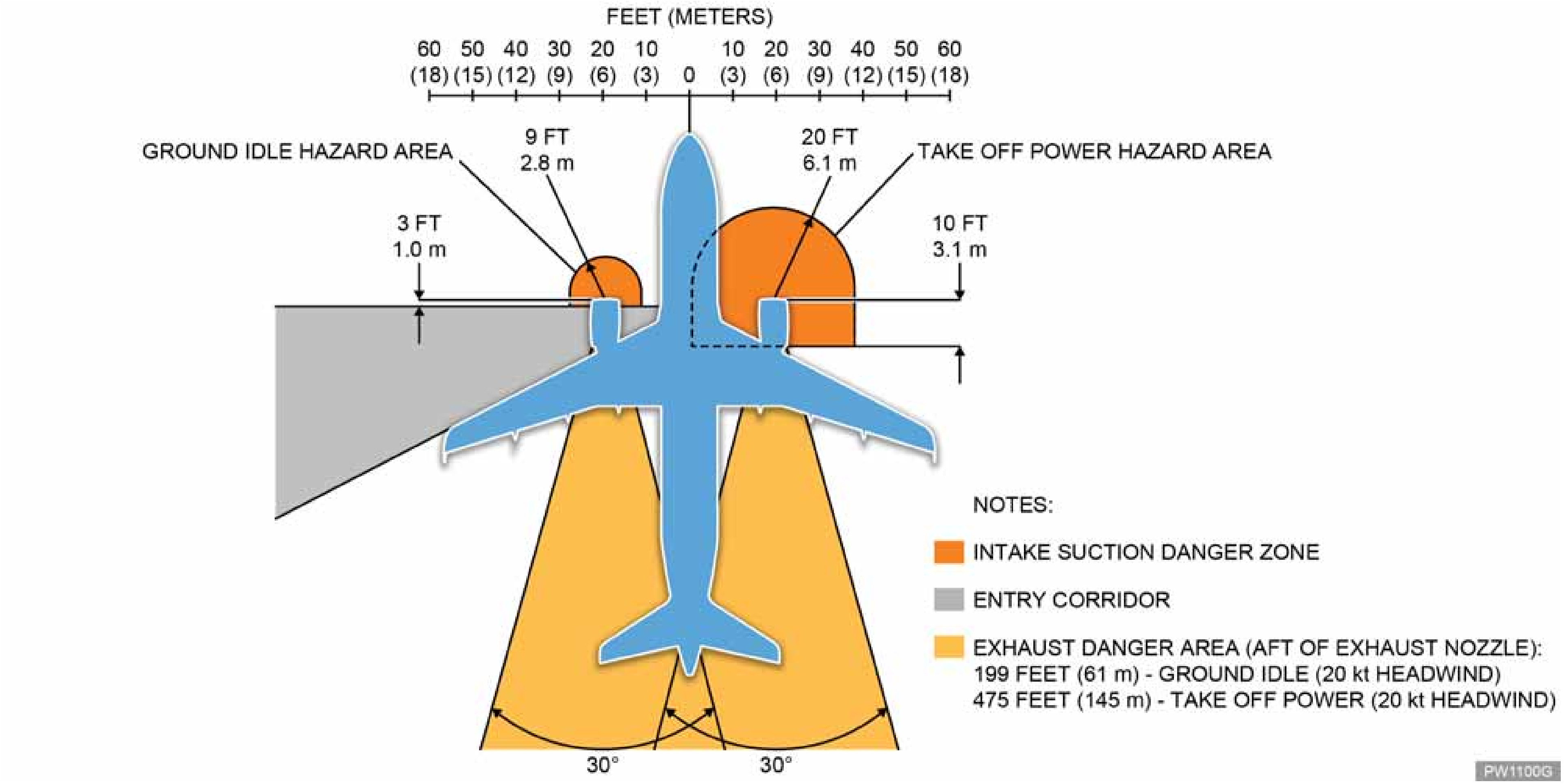


DRAINAGE SYSTEM

ENGINE GROUND RUN DANGER ZONES

The high velocity, high temperature, and toxicity of discharged exhaust gases can be dangerous. Jet wakes in the exhaust area can be significant. Some dangers include burn injuries, hearing loss due to extreme noise, ingestion of gases and exhaust, and proximity to other aircraft and ground support equipment.

Entry corridors and hazard areas are shown for personnel guidance when approaching an operating engine.



ENGINE GROUND RUN DANGER ZONES

PRESERVATION AND REPLACEMENT

Preservation of the Engine

Engine preservation provides maximum protection to critical engine components such as gears, bearings, and accessory components against damage from excessive moisture, debris, and other environmental conditions.

Preservation is used for the protection of out-of-service engines, whether on-wing or off, and for engines to be put into storage.

Preservation methods include:

- Method 1: *Preserve The Engine For 60 Days Or Less*
- Method 2: *Preserve The Engine For More Than 60 Days*.

Use the preservation method that is necessary for the time that the engine will be in storage. If you are not sure as to the length of storage time, use Method 2.

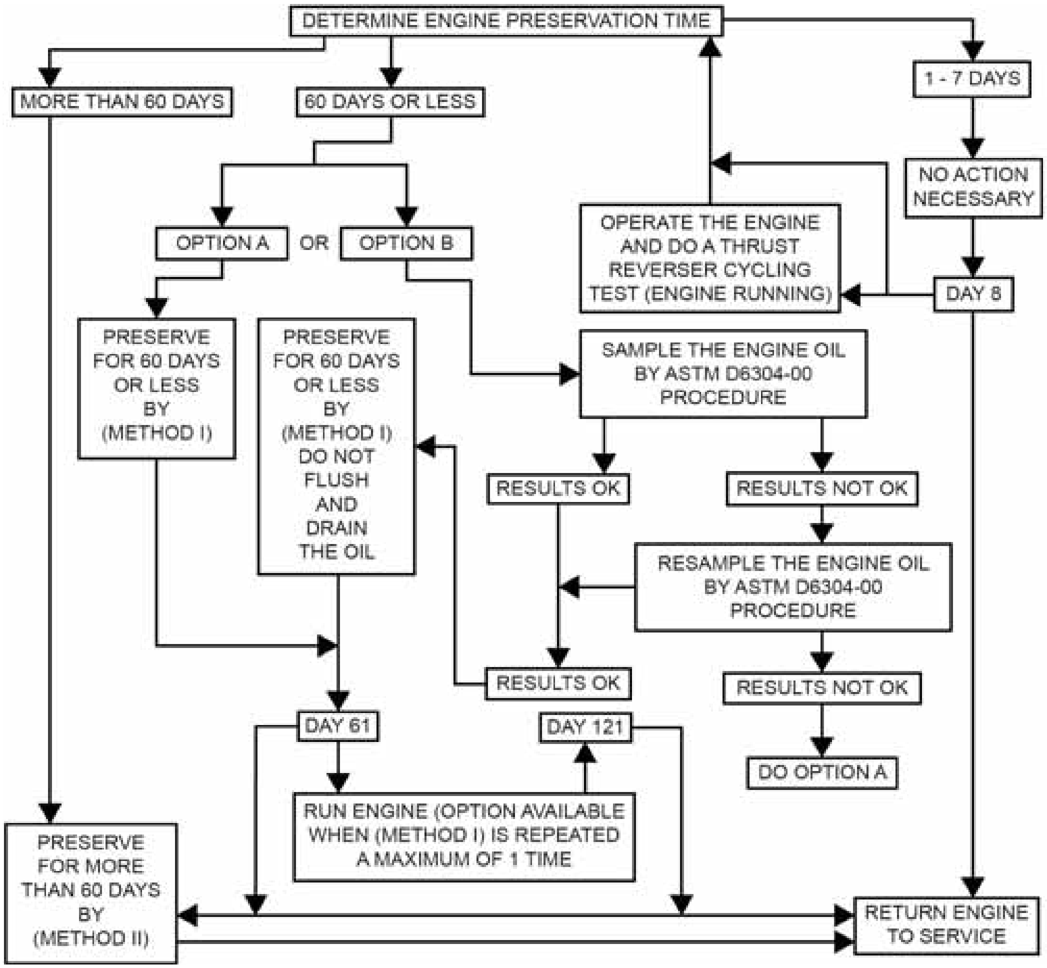
Safety Conditions

CAUTION

USE CARE IN LOCATIONS WHERE SEVERE TEMPERATURE CHANGES, SEVERE HUMIDITY, OR SALT WATER COULD CAUSE A HIGHER RISK OF DAMAGE TO ENGINE PARTS.

DO NOT OPERATE THE STARTER FOR MORE THAN THE FIVE MINUTES MAXIMUM STARTER TIME LIMIT. IF YOU DO, YOU CAN CAUSE DAMAGE TO THE STARTER.

DO NOT LET HYDRAULIC FLUID STAY ON THE MAIN GEARBOX DURING THE PRESERVATION PERIOD. HYDRAULIC FLUID CAN CAUSE CORROSION AND DAMAGE TO THE GEARBOX HOUSING.



NOTES TO THE PRESERVATION CHART:

1. THIS CHART DOES NOT SPECIFY ALL OF THE STEPS IN THE PRESERVATION METHOD.
2. SAMPLING OPTION IS RESTRICTED TO ONE 60 DAY PERIOD.
3. IN OPTION B, OIL SYSTEM FLUSH IS NOT NECESSARY (REF. METHOD I) IF SAMPLE TEST RESULTS ARE OK.
4. WHEN PRESERVING FOR MORE THAN 60 DAYS, FUEL SYSTEM PRESERVATION IS ALSO NECESSARY.
5. IF THE ENGINE WILL STAY IN STORAGE AFTER 60 DAYS (METHOD I), YOU CAN PRESERVE THE ENGINE AGAIN AFTER THE INITIAL 60-DAY PERIOD. SEE TEXT FOR INSTRUCTIONS.

PW1100G

PRESERVATION CHART

PRESERVATION AND REPLACEMENT (Cont.)

Method 1: Preservation of Engine for 60 Days or Less

Preserve the Engine Oil System

- Change the engine oil. Drain, replace oil filter and fully service the system.
- Motor the engine for five minutes. The fan must be turning.
- Drain the oil system and remove the oil filter.

Preserve the Gearbox

- Inspect the housing for hydraulic fluid, and clean according to standard practices.
- Spray oil on the gearbox pads and install pad covers.

Preserve the Engine for Relative Humidity

- Put dehydrating agent in the engine. Put half in the inlet and half in the exhaust areas.

Seal the Engine for Storage

- Install covers over the engine intake area.
- Install a cover over the engine exhaust area.

Make a Record of Preservation for Each Engine

The record should note the following information:

- method of preservation
- date of preservation
- oil system is drained and empty.

PRESERVATION AND REPLACEMENT

Method 1: Preservation of Engine for 60 Days or Less (Cont.)

If the engine will continue to stay in storage for more than the 60 day limit, you can choose between the two options listed below.

- Option 1: *Preserve the Engine For More Than 60 Days* (Method 2)
- Option 2: Operate the engine

Option 2 may only be used to repeat *Preserve the Engine For 60 Days Or Less* a maximum of one time. Option 2 may not be used if the engine stays in storage more than a total of 120 days. If the engine is to remain in storage longer than 120 days, then it is necessary to preserve the engine using Method 2, *Preservation of Engine For More Than 60 Days.*

PRESERVATION AND REPLACEMENT (Cont.)

Method 2: Preservation of Engine for More Than 60 Days

It will be necessary to air motor or run the engine in a Test Cell to preserve the engine for more than 60 days.

Preserve the Engine Oil System

- Change the engine oil. Drain, replace the oil filter, and fully service the system.
- Motor the engine for five minutes. The fan must be turning.
- Drain the oil system after fuel system preservation and remove the oil filter.

Preserve the Engine Fuel System

- Drain the fuel system by removing the plug from the Fuel/Oil Manifold below the IFPC. Then re-install the plug.
- Attach the fuel preservation adapter and drain tube.
- Use the preservation cart to pump preservation fluid into the system while wet motoring the engine.
- Remove tooling and reconnect the fuel lines.

Change Starter Oil

- Refer to Aircraft Maintenance Manual.

Preserve the Gearbox

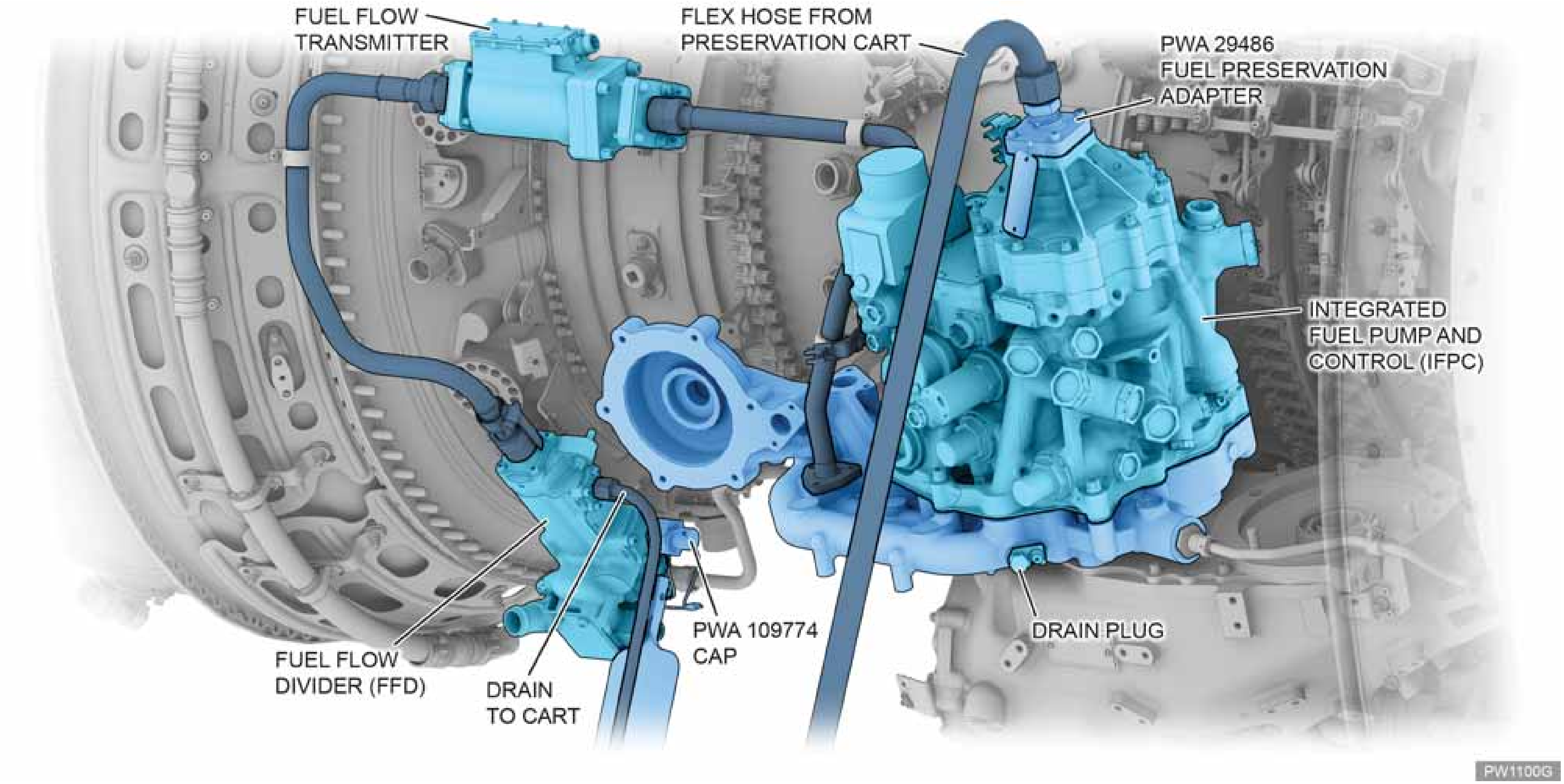
- Inspect the housing for hydraulic fluid, and clean according to standard practices procedures.
- Spray oil on the gearbox pads and install pad covers.

Preserve the Engine for Relative Humidity

Relative humidity must be at 40 percent or less inside the engine during the preservation time.

- Put dehydrating agent in the engine. Put half in the inlet and half in the tail pipe areas.
- Put relative humidity indicators inside the inlet and exhaust areas.
- Seal the engine for storage.
- Install covers over the engine intake area.
- Install cover over the engine exhaust area.

Protective covers must have windows so that you can see the relative humidity indicators inside the engine.



ENGINE FUEL SYSTEM PRESERVATION

PRESERVATION AND REPLACEMENT

Method 2: Preservation of Engine for More Than 60 Days (Cont.)

Make A Record for Each Engine

Make a record with the following information:

- method of preservation
- date of preservation
- confirmation that oil system is drained and empty.

Storage

Examine the engine during preservation (every 15 days or less) and refer to General Instructions For The Preservation of Engines for Storage, SPOP 428.

Safety Conditions

CAUTION

THE BOOTSTRAP HOIST CHAINS MUST BE ALONGSIDE THE ENGINE WHEN YOU USE THE CHAINS. IF NOT, THE CHAINS CAN HIT AND DAMAGE THE ENGINE.

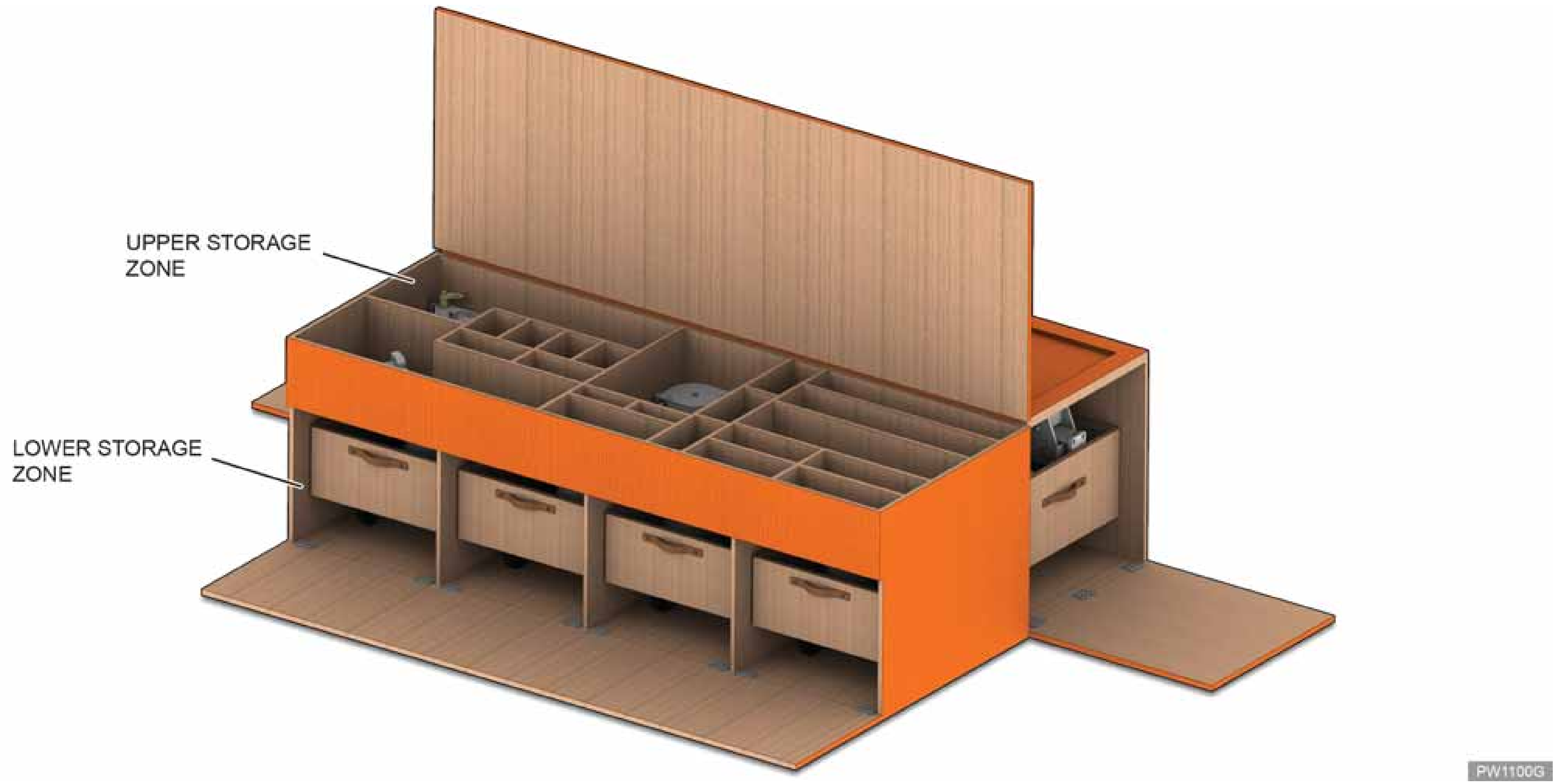
ENGINE REMOVAL AND INSTALLATION

Bootstrap Procedure

The bootstrap procedure removes the engine from its mount on the pylon and subsequently installs it to the pylon.

The bootstrap kit containing the required tooling for the process is housed in a large storage case designated as Engine Bootstrap Assembly 98 D71203011000.

The case is split into upper and lower storage zones.



ENGINE BOOTSTRAP ASSEMBLY KIT 98 D71203011000

ENGINE REMOVAL AND INSTALLATION

Bootstrap Procedure (Cont.)

Upper Storage Zone

The upper storage zone is accessed by opening the top panel of the case. It contains 24 pieces of bootstrap tooling.

Upper storage zone tools listed in the table are shown in the graphic below with corresponding letters.

Letter	Tooling	Quantity
A	Forward central beam	1
B	Left forward arm	1
C	Right forward arm	1
D	Aft central beam	1
E	Left aft arm	1
F	Right aft arm	1
G	Cable assembly	1
H	Forward support assembly	1
I		1
J	Aft support assemblies	2
K	Clevis assemblies (fixed)	3
L	Chain hoists	2
M	Cover assemblies	2
N	Hoisting beam assemblies	2
P	Four-ton dynamometers	3
Q	Clevis assembly	1

BOOTSTRAP ASSEMBLY KIT – UPPER STORAGE ZONE TOOLS

ENGINE REMOVAL AND INSTALLATION

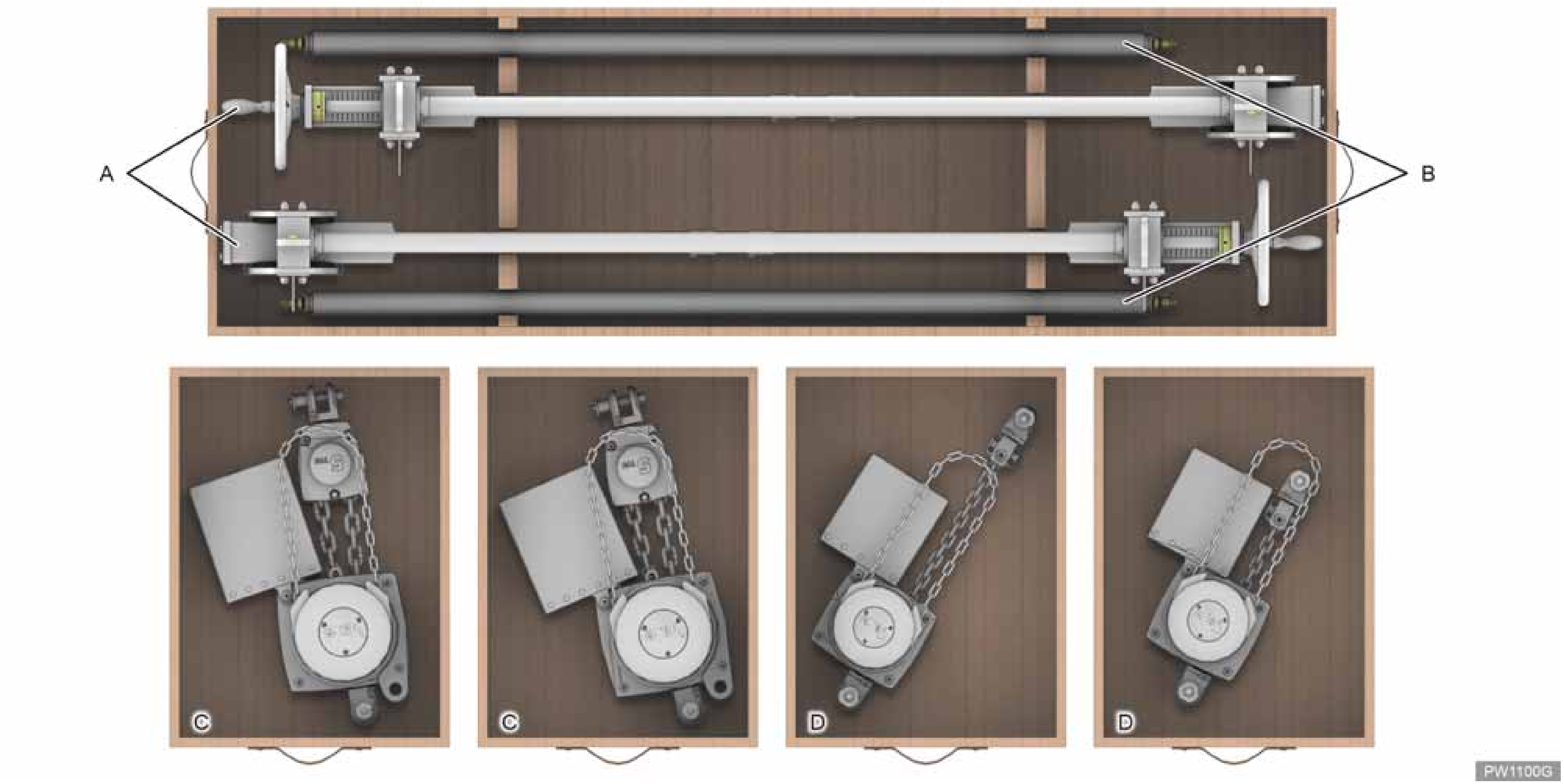
Bootstrap Procedure (Cont.)

Lower Storage Zone

Lower storage zone tools are accessed by opening the lower front and lower right panels of the case. The panels are hinged to open downward towards the floor and are used as ramps to access and remove five wheeled containers that hold the lower storage zone hardware.

Removing the wheeled containers will give access to the eight pieces that make up the chain hoist and its assembly tools. See the table at right.

Letter	Tooling	Quantity
A	Track assemblies	2
B	Hoisting beam assemblies	2
C	5-ton chain hoists	2
D	2 -ton chain hoists	2



BOOTSTRAP ASSEMBLY KIT – LOWER STORAGE ZONE TOOLS

ENGINE REMOVAL AND INSTALLATION

Bootstrap Procedure (Cont.)

Bootstrap System

First the engine is removed from the pylon using the bootstrap system and lowered to a cradle supported by a transportation stand. Later the engine is raised by the chain hoist for installation to the pylon mount.

Transport Stand PWA211430

The transport stand is used to move the engine when it is not installed on the aircraft. It has all of the hardware necessary to move the engine during ground handling.

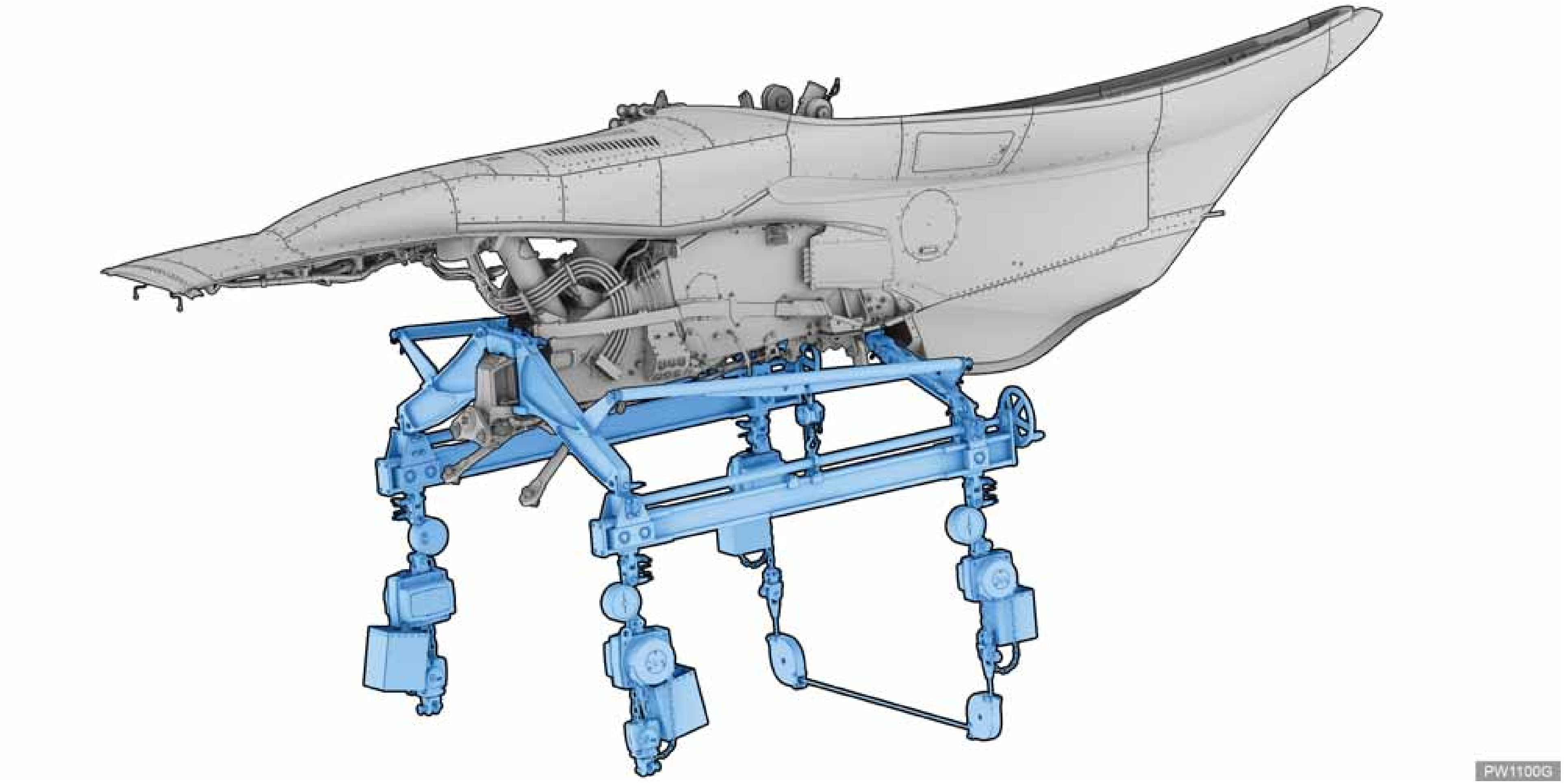
Cradle

The cradle portion of the transport stand supports the engine when the engine is removed from the aircraft pylon and lowered.

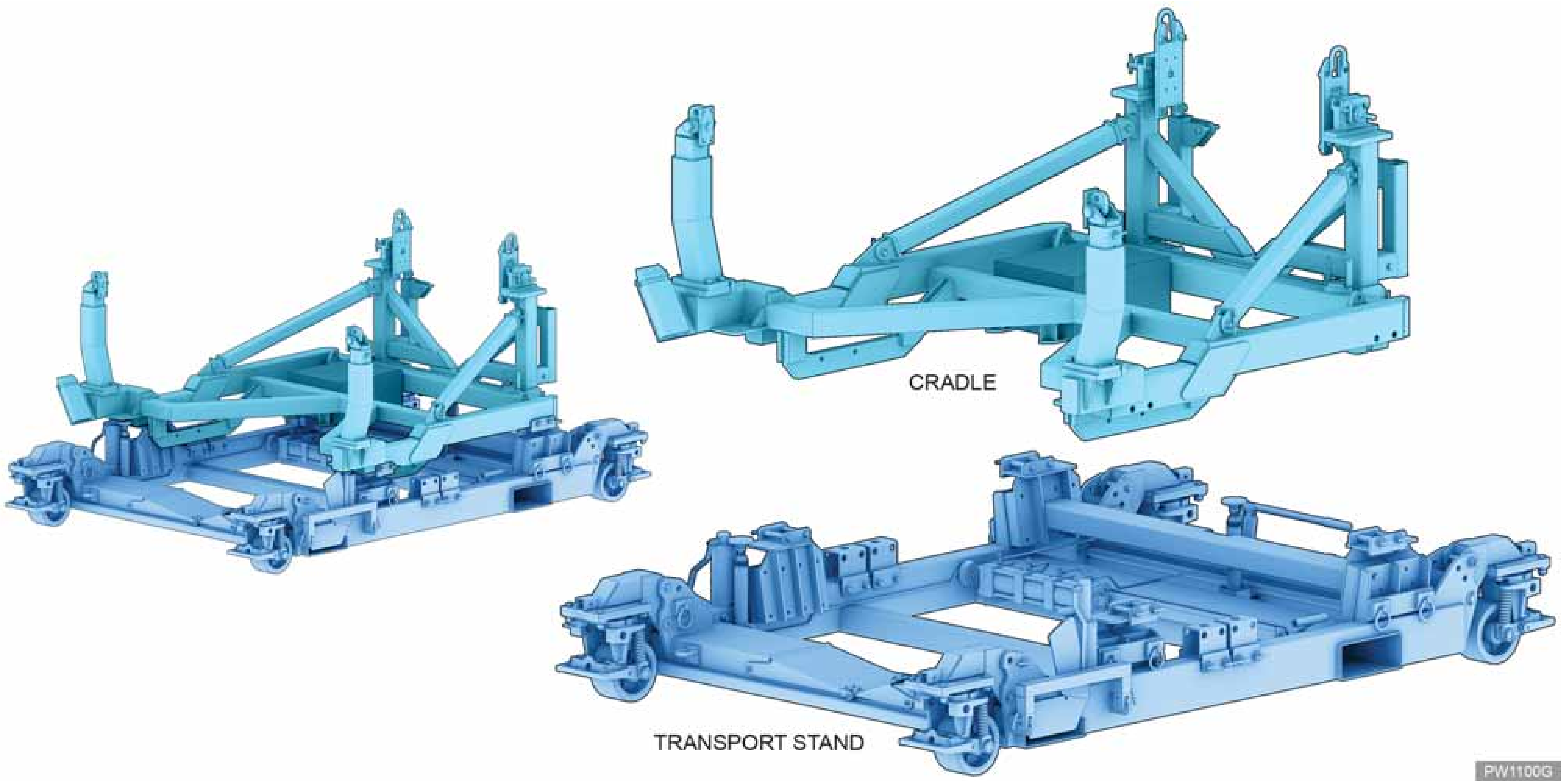
Safety Conditions

CAUTION

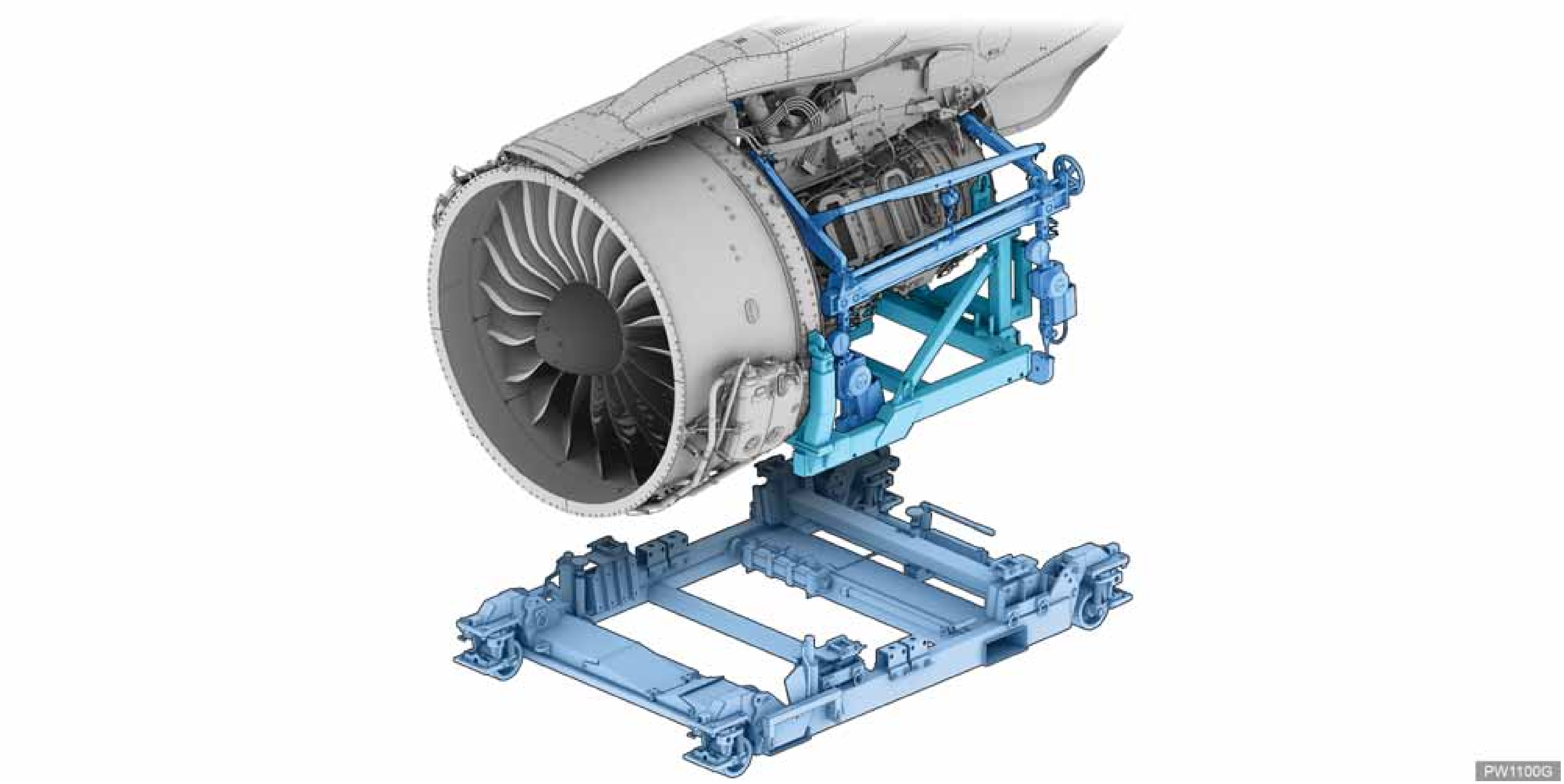
CAREFULLY MONITOR ALL DISCONNECTED TUBES, DUCTS, AND HARNESSES TO MAKE SURE OF SUFFICIENT CLEARANCE AS THE ENGINE IS LOWERED. IF YOU DO NOT, DAMAGE TO THE ENGINE OR AIRCRAFT CAN OCCUR.



BOOTSTRAP SYSTEM CHAIN HOIST



ENGINE REMOVAL/INSTALLATION SUPPORT EQUIPMENT



BOOTSTRAP PROCEDURE – ENGINE READY FOR REMOVAL

CHAPTER 2

ENGINE CONSTRUCTION

ATA 72

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT	A Post Maintenance Test is required.
WARNING	Avoid injury by following guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

Safety Conditions

WARNING

REFER TO THE MSDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DON NOT OBEY THIS WARNING, INJURY CAN OCCUR.

OBJECTIVES

1. Recognize engine specifications.
2. Locate engine features shown below.
   - Modules
   - Flanges
   - Stations
   - Bearings
3. Explain the function of the Fan Drive Gear System (FDGS).
4. Identify Line Replaceable Units (LRUs)

GASPATH CONFIGURATION

Gaspath configuration is a term describing the engine modules that make up the primary path of airflow through the engine. A *module* is an assembly of parts that can be installed or removed from the engine as a single unit.

Gaspath modules and their stage counts are listed below. Each stage is made up of a single rotor assembly and its complementing stator assembly. Note that in the compressor section, the rotor precedes the stator. In the turbine section, the rotor follows the stator.

Secondary air is used for cooling. After the air is used, it will return to the engine gaspath or be vented overboard.

Secondary air cools the following:

- rotor cavities
- turbine blades and vanes
- combustion case
- turbine case
- exhaust case.

Module		Stage Count
Fan rotor		1
Fan Intermediate Case	FIC	N/A
Low Pressure Compressor	LPC	3
Compressor Intermediate Case	CIC	N/A
High Pressure Compressor	HPC	8
Diffuser and combustor		N/A
High Pressure Turbine	HPT	2
Turbine Intermediate Case	TIC	N/A
Low Pressure Turbine	LPT	3
Turbine Exhaust Case	TEC	N/A

GASPATH CONFIGURATION

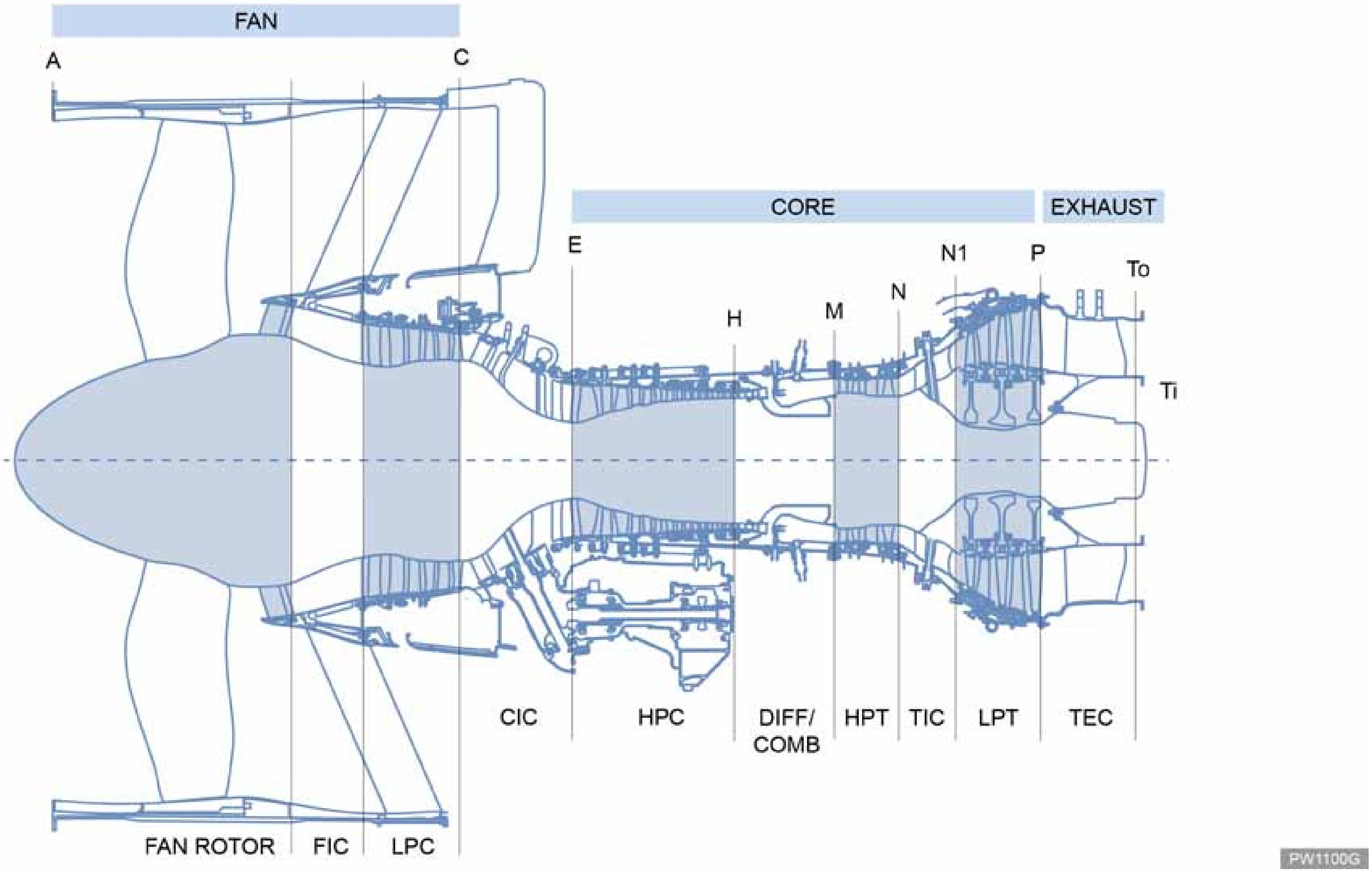
ENGINE FLANGES

Engine flanges are external features of the engine case that serve various structural purposes, including:

- joining module assemblies together
- supporting the engine's streamlined enclosure known as the *nacelle*
- supporting the brackets used to mount engine components.

Flanges and the modules and attachment points they support are detailed at right. They are shown in conjunction on the graphic below.

Flange	Modules and Attachment Points		
A	Fan	Inlet cowl	
C		V groove	
E	Core	High Pressure Compressor	HPC
H		Diffuser case	
M		High Pressure Turbine	HPT
N		Turbine Intermediate Case	TIC
N1		Low Pressure Turbine	LPT
P	Turbine Exhaust	Turbine Exhaust Case	TEC
To		Exhaust sleeve nozzle	
Ti		Exhaust plug	



ENGINE FLANGES AND MODULES

ENGINE STATIONS

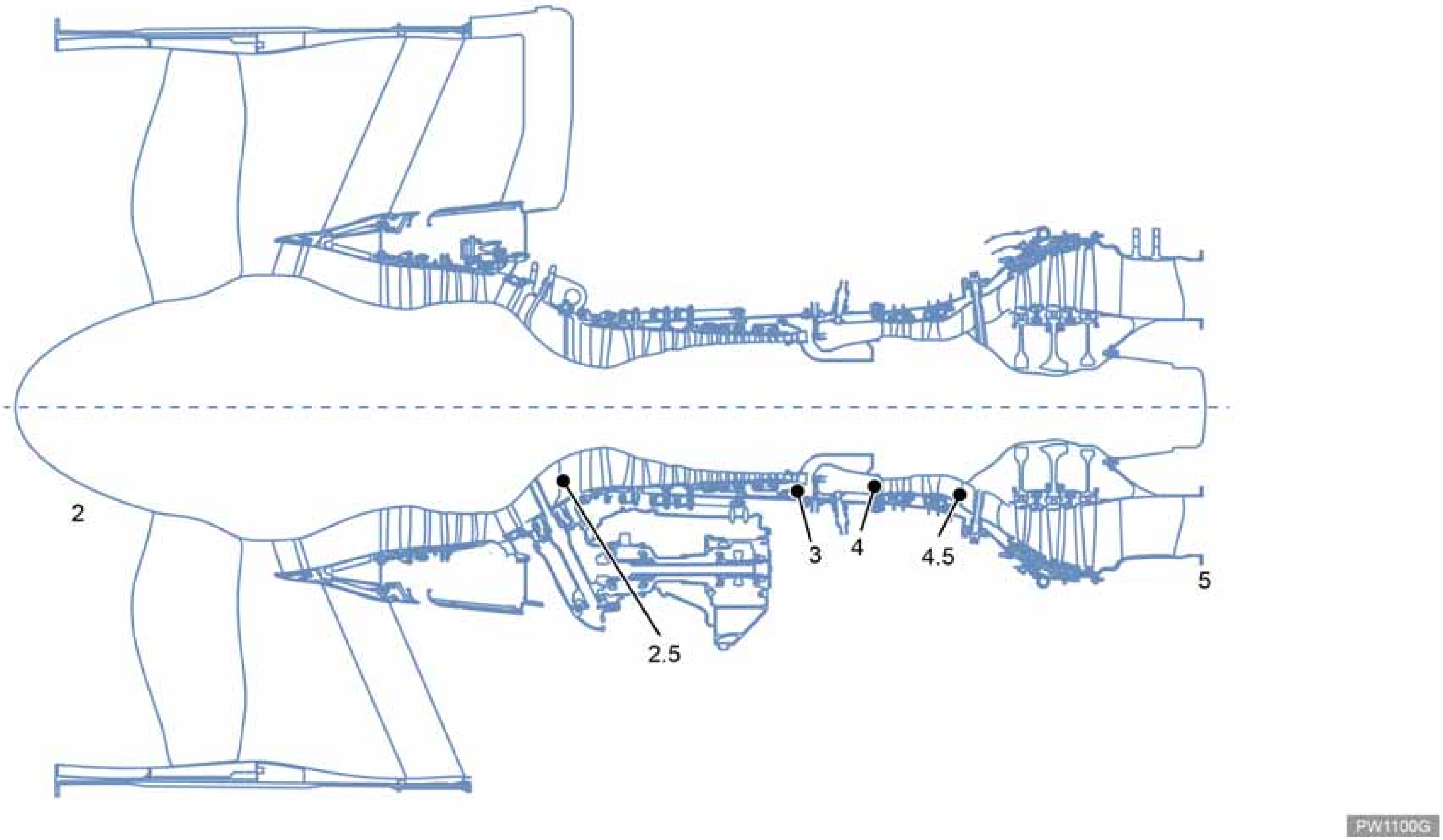
Engine stations identify significant locations in the gaspath, often marking probes and sensors that gather information for pressure or temperature. Signals from the probes and sensors are transmitted through the engine's electronic control component to the flight deck.

Each sensor uses the number of the engine station as part of its name. Examples are shown below.

Sensor	**Naming Convention**
T3	T = Temperature 3 = Station 3
PT2.5	PT = Pressure and Temperature 2.5 = Station 2.5

Stations are illustrated in the graphic below.

Station	Location
2	Engine core inlet
2.5	LPC exit
3	HPC exit
4	HPT inlet
4.5	HPT exit
5	Exhaust
14	Aft Fan Exit Guide Vane



ENGINE STATIONS

ENGINE MAIN BEARINGS

Bearings support the weight of engine parts and permit one surface to roll over another with minimal friction and wear. The weight of the engine parts is transmitted through balls or rollers that are contained by two raceways. The load is transferred from the inner raceway to the outer raceway.

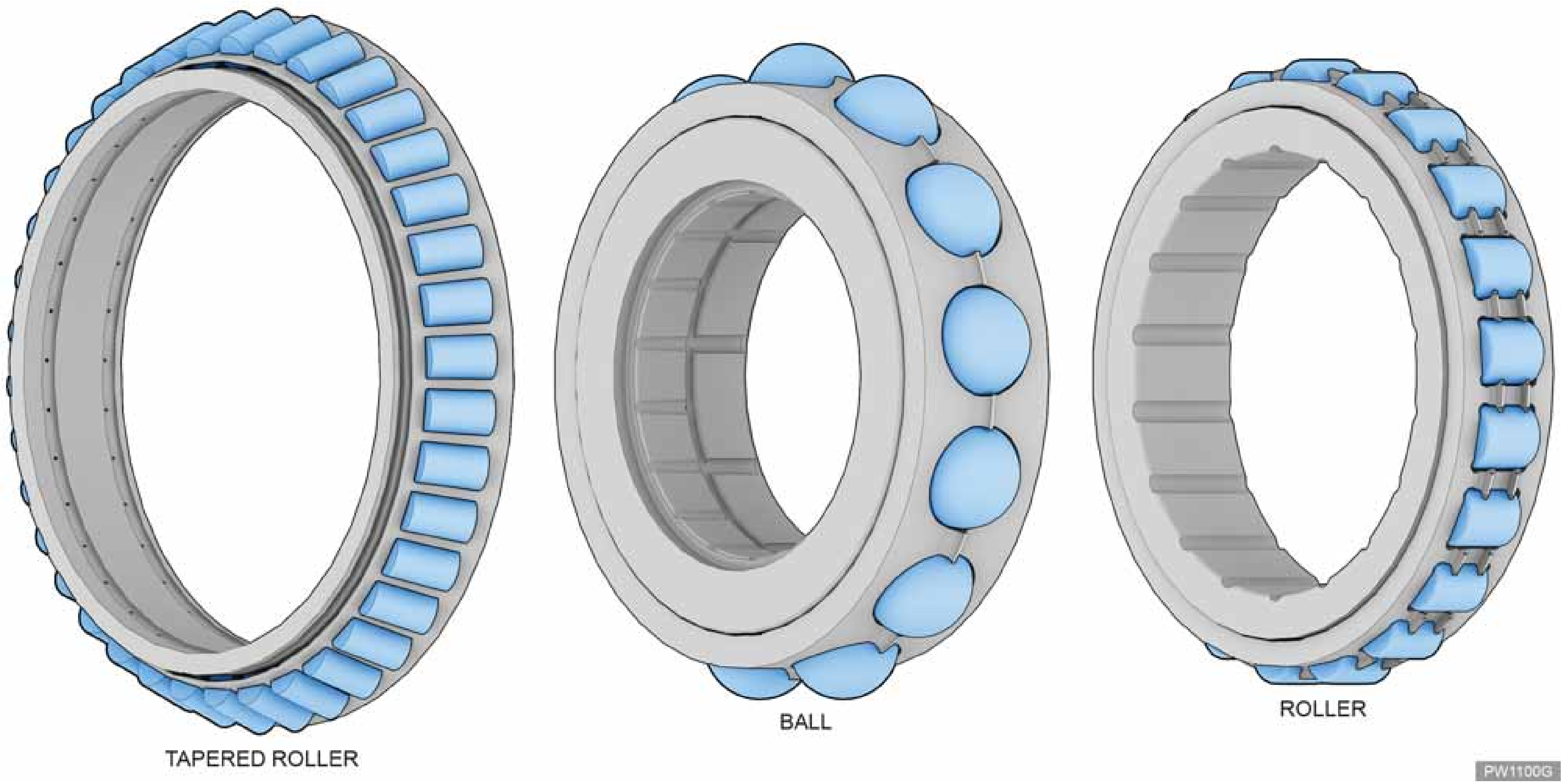
Ball bearings have a single point of contact, allowing the bearings to spin smoothly. In contrast, roller bearings have an entire line of contact and can support heavier loads distributed over a large area. Tapered roller bearings operate like ball bearings, while requiring less space than standard roller bearings.

The three bearing types are designed to withstand extreme pressure as they transmit the different types of loads shown in the chart. An axial load is transmitted parallel to the bearing shaft, and a radial load is applied perpendicular to the shaft. As they transfer the weight of axial and radial loads, the bearings hold the engine parts in alignment.

Bearings are lubricated, cooled, and cleaned by oil.

The PW1100G-JM uses all three types of bearings, illustrated in the graphic below.

Bearing Type	Alignment and Load
Roller	Radial
Ball	Axial and radial
Tapered roller	



TYPES OF BEARINGS

ENGINE MAIN BEARINGS (Cont.)

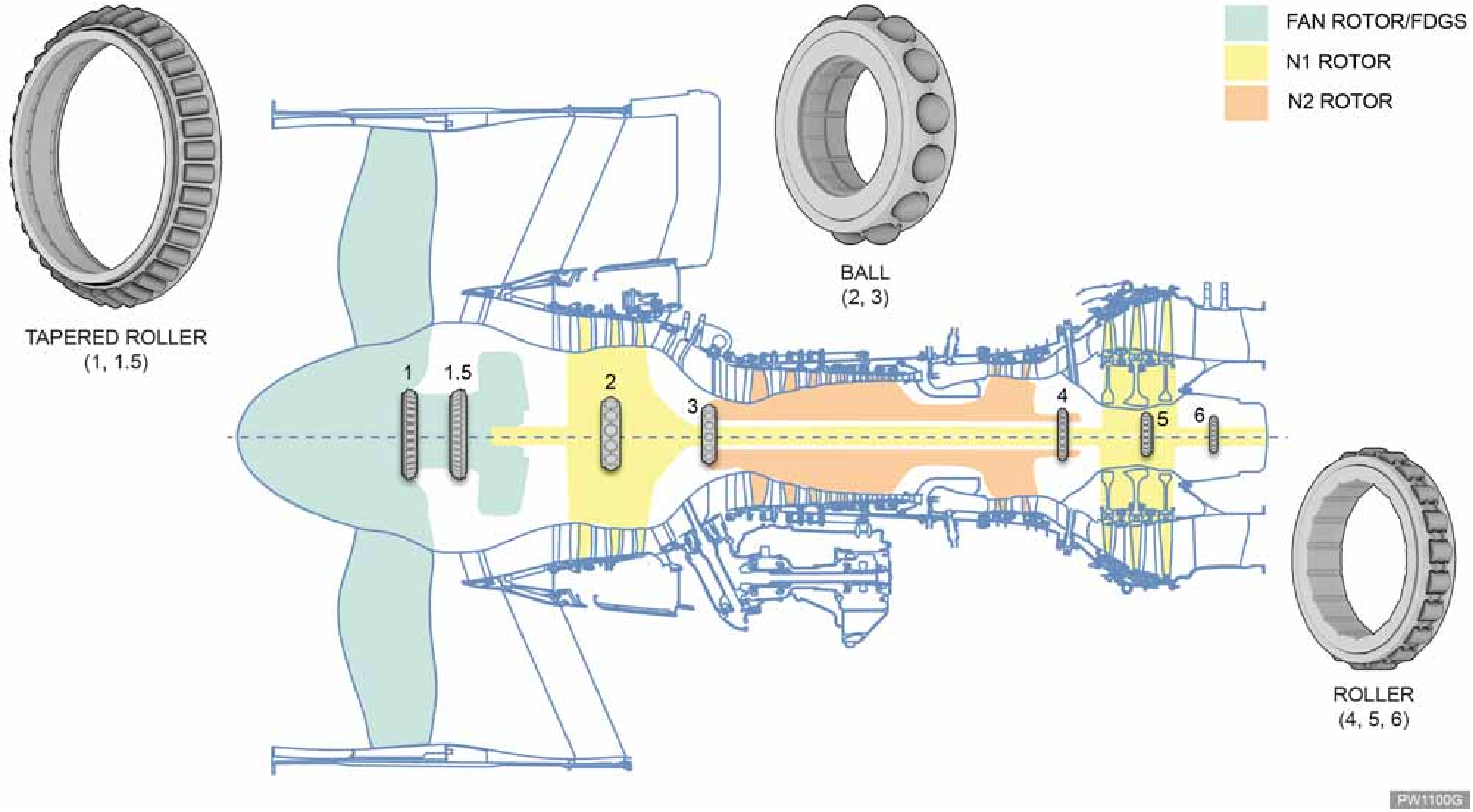
Five compartments contain a total of seven bearings. Descriptions are shown in the chart. Locations throughout the engine are displayed on the graphic below.

Oil-damped bearings use a thin film of oil between the outer race and the bearing support to reduce vibration.

NOTE

The low pressure and high pressure rotors are often referred to as *N1* and *N2,* respectively.

Compartment	No.	Type	Damped	Module	Support Function
Front Bearing	1	Tapered roller	✓	Fan Intermediate Case	Fan rotor and Fan Drive Gear System (FDGS)
	1.5				
	2	Ball	✓		Front of N1 rotor (LPC)
No. 3	3		✓	Compressor Intermediate Case	Front of N2 rotor (HPC)
No. 4	4	Roller	✓	Turbine Intermediate Case	Rear of N2 rotor (HPT)
No. 5/6	5			Turbine Exhaust Case	Rear of N1 rotor (LPT)
	6		✓		



ENGINE MAIN BEARING LOCATIONS

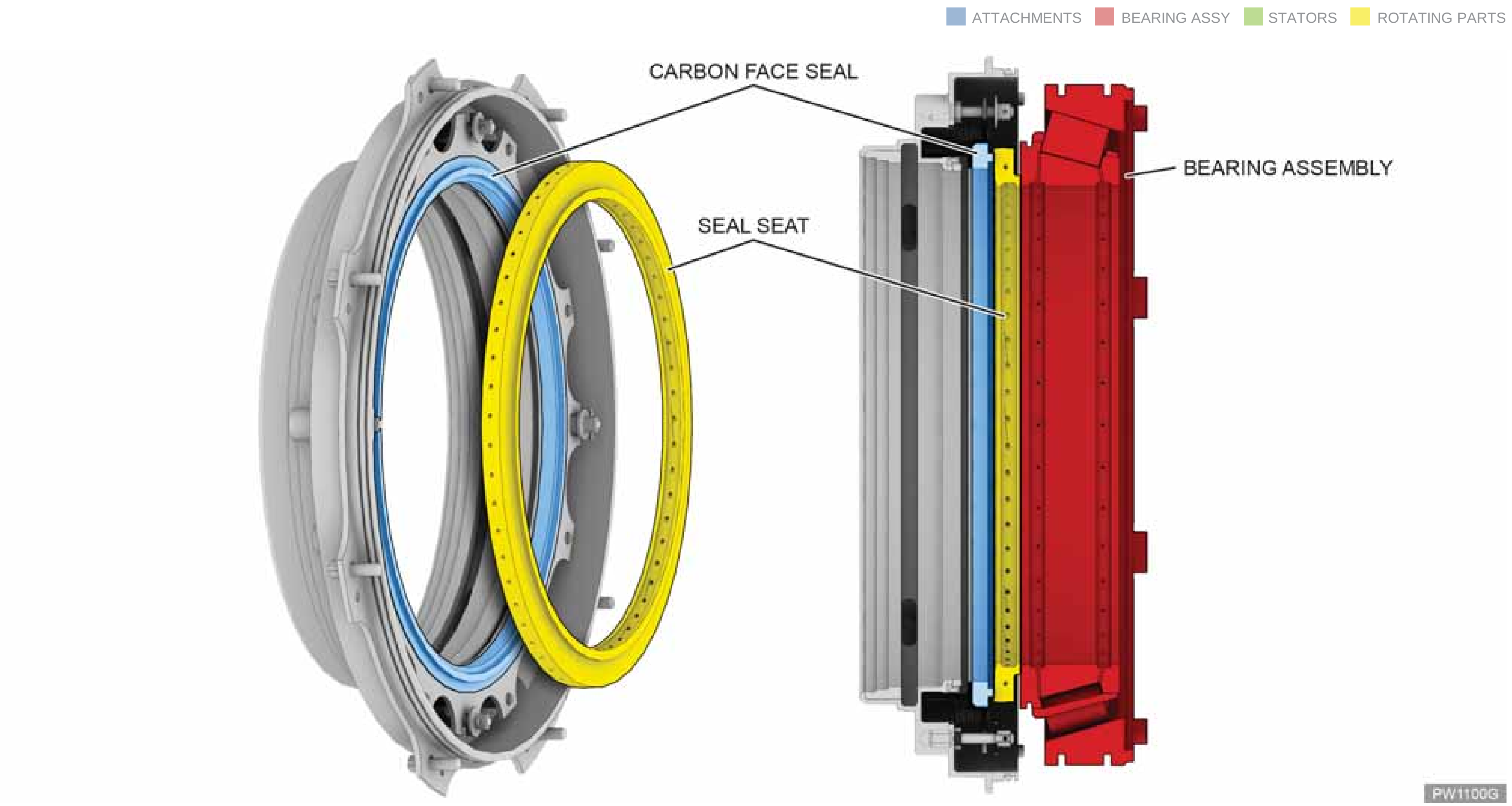
ENGINE MAIN BEARINGS (Cont.)

Bearing Compartment Hardware

Each bearing compartment uses carbon seals to prevent oil leakage.

Static carbon face seals fit against a rotating seal seat.

The No. 4 Bearing compartment has a scupper that collects any leakage oil and directs it to the overboard breather vent.



ENGINE MAIN BEARING COMPARTMENT HARDWARE

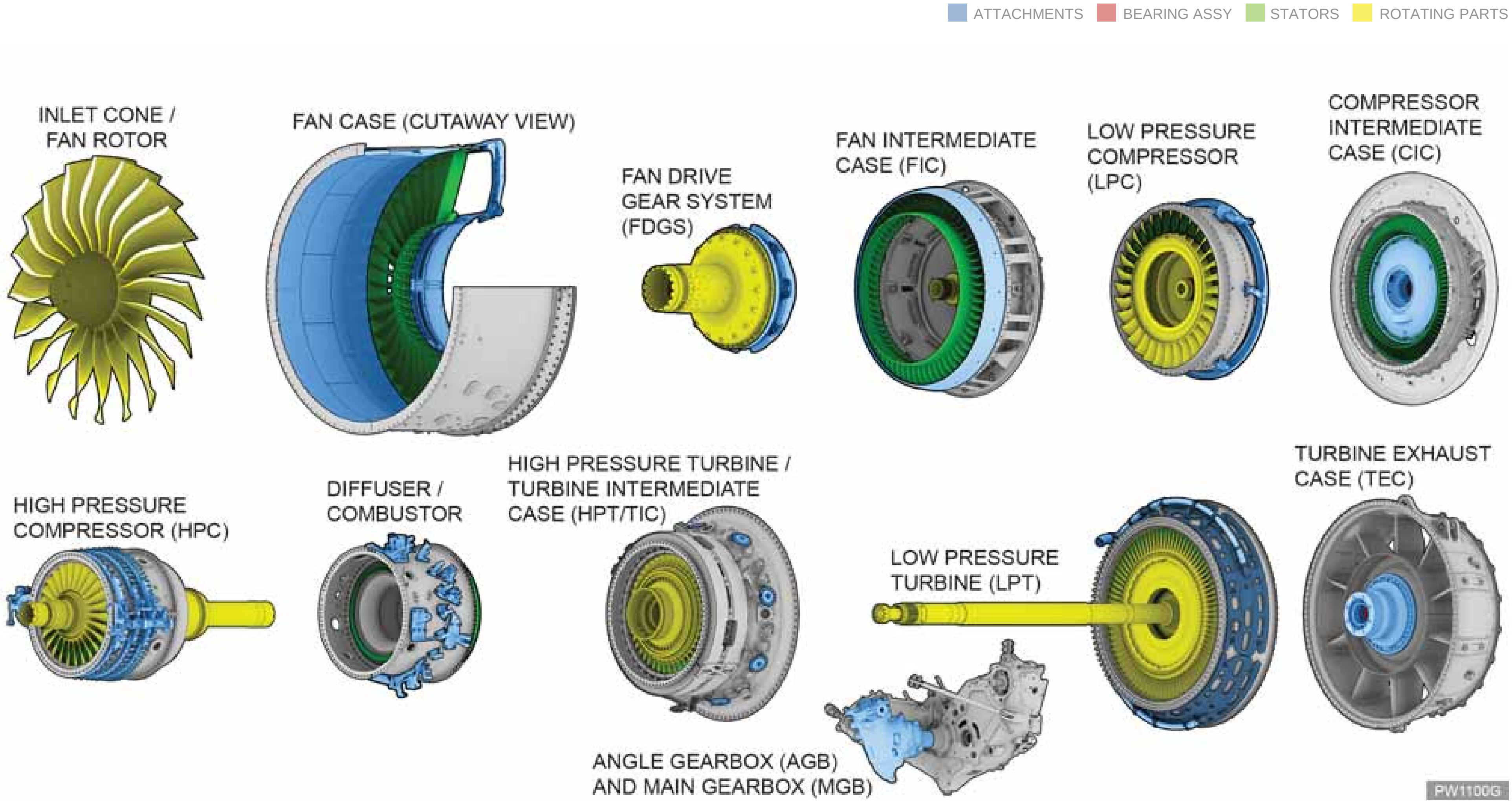
ENGINE MODULES

A module is the largest assembly of engine parts that can be treated in one of two ways:

- removed or installed from the engine as a unit
- disassembled or preassembled, independently of other modules.

PW1100G-JM assembly modules are as follows.

• Fan rotor (including inlet cone)	
• Fan case	
• Fan Drive Gear System	FDGS
• Fan Intermediate Case	FIC
• Low Pressure Compressor	LPC
• Compressor Intermediate Case	CIC
• High Pressure Compressor	HPC
• Diffuser/Combustor/High Pressure Turbine nozzle	
• High Pressure Turbine	HPT
• Turbine Intermediate Case	TIC
• Low Pressure Turbine	LPT
• Turbine Exhaust Case	TEC
• Main Gearbox	MGB
• Angle Gearbox	AGB



ENGINE MODULES

ENGINE MODULES (Cont.)

Fan Rotor

Purpose:

The fan rotor draws in ambient air and provides the first of 12 stages of compression. The fan produces more than 90 percent of the thrust produced by the engine.

Location:

The fan rotor is located at the front of the engine. The inlet cone and cover are at the front of the fan rotor.

Description:

The fan rotor includes the inlet cone and 20 fan blades. Fan diameter is 81 inches.

The fan rotor is connected to the fan drive shaft and is supported by bearing nos. 1 and 1.5, which are tapered roller bearings.

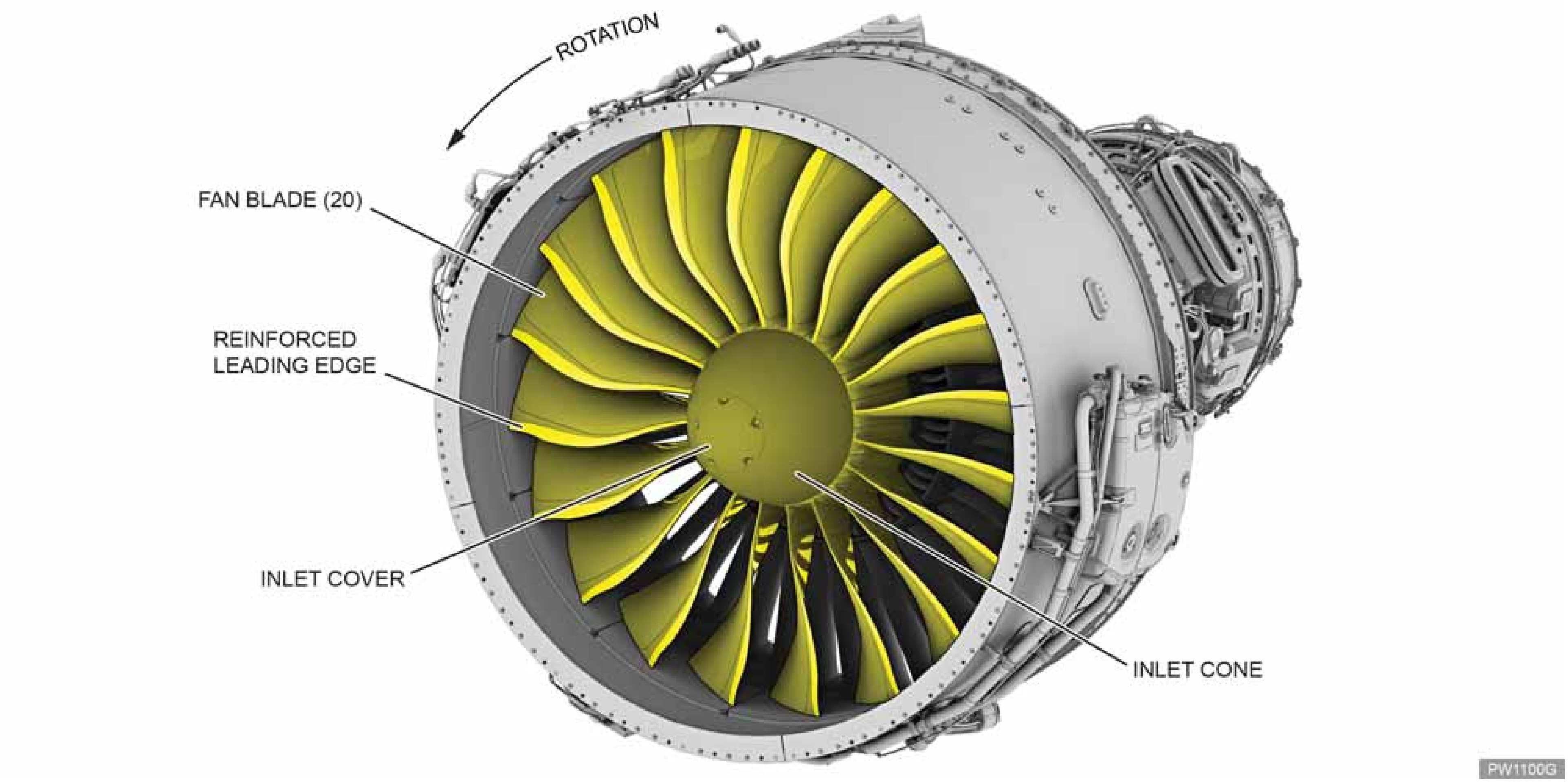
The engine has a total of 12 compression stages, including the fan.

Operation:

Power to turn the fan is supplied by the fan drive gear through the fan drive shaft. The fan rotates in a clockwise direction as viewed from the aft end of the engine looking forward.

> KEY CONCEPT
>
> The gears of the Fan Drive Gear System (FDGS) reduce the speed of the LPC input, providing a slower output speed to the fan and improving fan efficiency.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



FAN ROTOR

ENGINE MODULES (Cont.)

Inlet Cone

Purpose:

LRU PMT

At the front of the rotor, the inlet cone and its cover smooth the flow of air to the engine.

Location:

The inlet cone is attached to the fan hub.

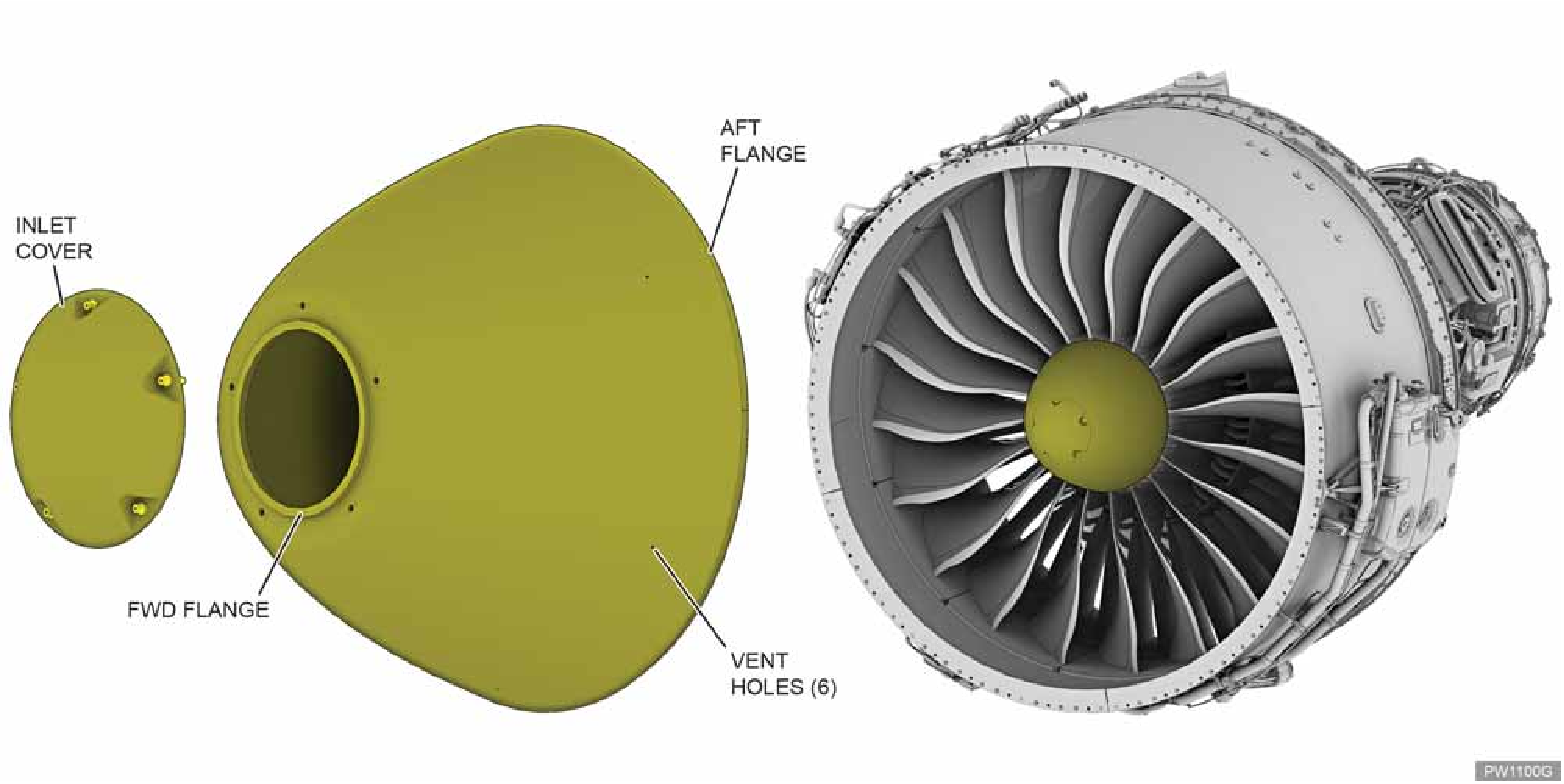
Description:

The inlet cone is made of composite material. Its forward flange provides attachment for the inlet cone cover.

The inlet cone's aft flange is bolted to the fan hub and is part of the fan blade retention system. A continuous flow of Station 2.5 air provides anti-icing for the inlet cone.

The cone has holes around its circumference for venting anti-ice air.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



INLET CONE

ENGINE MODULES

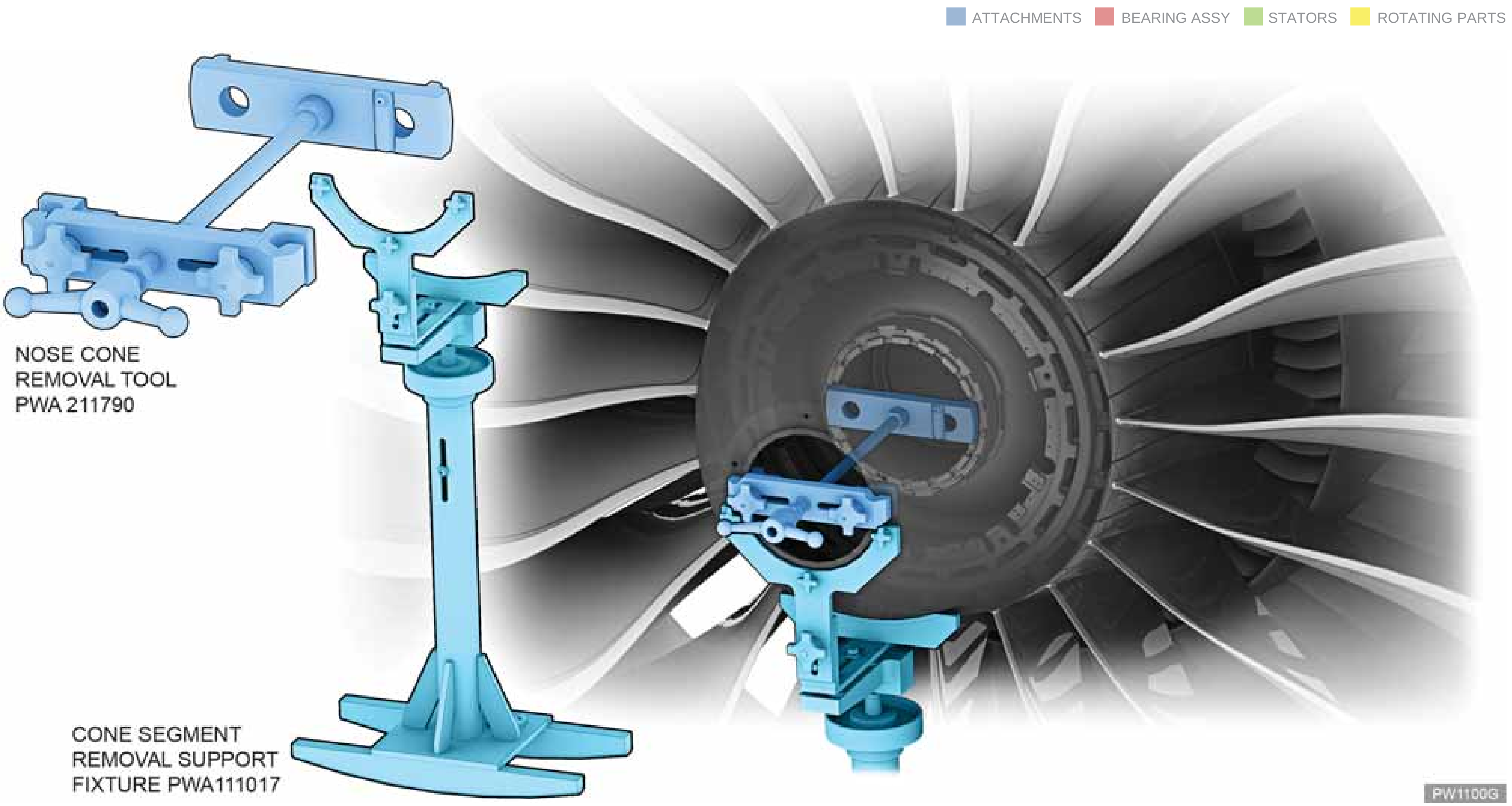
Inlet Cone (Cont.)

Inlet Cone Removal Tools

Cone segment removal support fixture PWA111017 is used to hold the spinner and tool when the spinner is removed from the fan hub. The support fixture has a welded aluminum base with a threaded rod and adjustment nut. The base is curved to seat along the inner diameter of the fan case. The top fixture is steel and slides on ball rollers. The adapter plate has three hand knob assemblies and is U-shaped.

Nose cone removal tool PWA211790 is used to pull the inlet cone from the fan hub. The puller tool has a large threaded rod with a fixed block that engages the fan hub on one end and an adjustable clamp that attaches to the inlet cone on the other end. Turning the threaded rod handle clockwise will draw the clamp away from the fan hub.

The inlet cone incorporates an alignment feature in its attachment flange to allow proper installation.



INLET CONE AND NOSE CONE REMOVAL TOOLS

ENGINE MODULES (Cont.)

Fan Blade

Purpose:

Fan blades accelerate the air entering the engine, producing the majority of thrust and providing airflow to the primary gaspath to be used for combustion and cooling.

Location:

Fan blades are located on the fan hub.

Description:

The 20 fan blades are partially hollow and made of aluminum, with a dovetail root to engage slots in the fan hub. Composite Teflon® wear strips are bonded to the pressure surfaces of each fan blade dovetail to prevent wear on the blade root pressure surfaces and to reduce fan rotor vibration.

Axial retention of the blades is provided by front and rear lock rings. Composite fan blade spacers are installed beneath the fan blades to provide a radial preload of the blades, which also reduces fan rotor vibration.

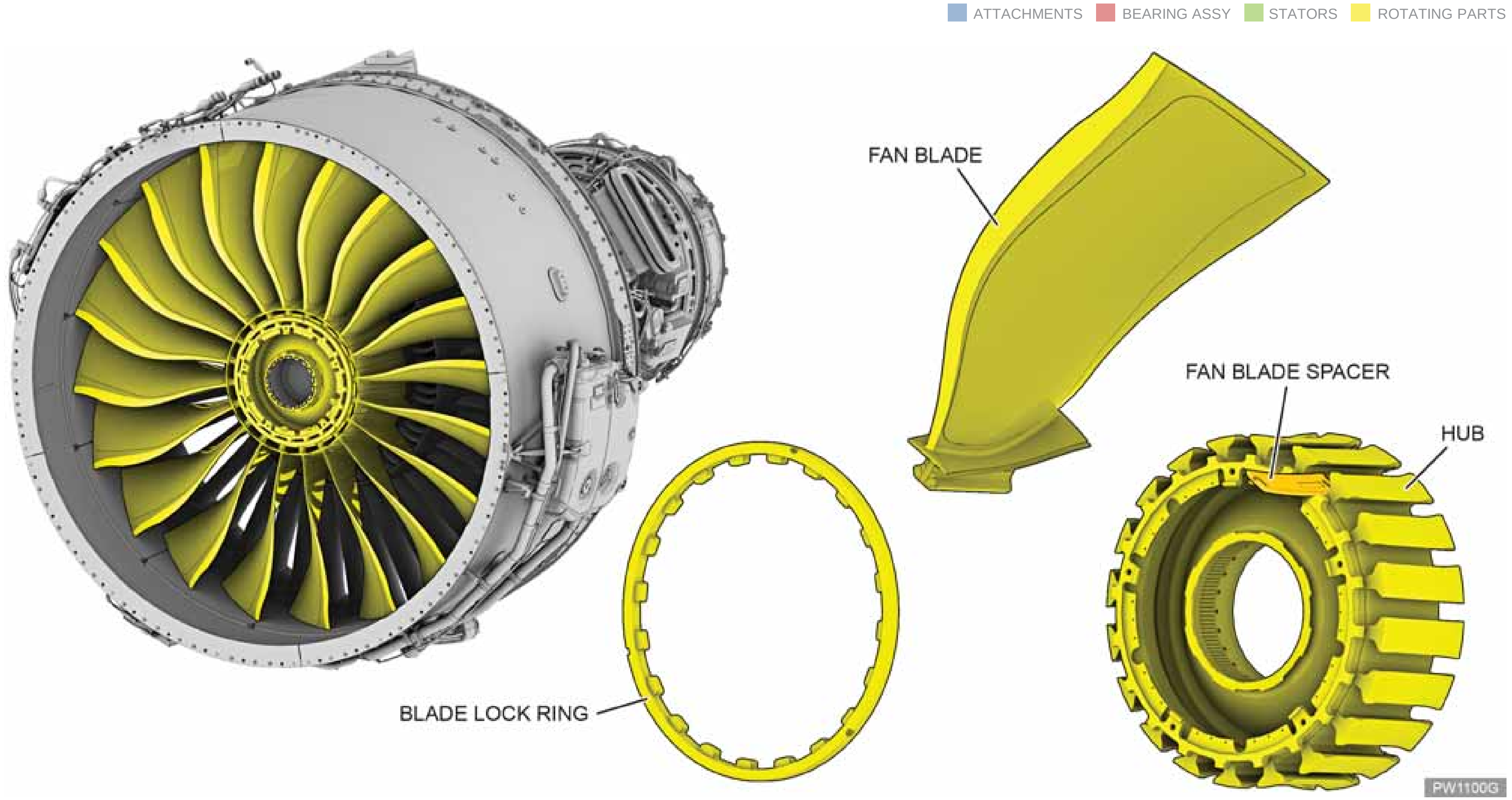
Safety Conditions

WARNING

USE PROTECTIVE GLOVES TO PREVENT POSSIBLE INJURY TO THE HANDS WHEN YOU HOLD THE FAN BLADES. THE BLADE EDGES ARE SHARP AND CAN CUT THE HANDS.

Spacers are mechanically trapped by the front and rear lock rings.

An erosion coating is applied on the airfoil and a titanium strip is bonded to the leading edge of each blade to reduce leading edge erosion.



FAN BLADE AND HUB

ENGINE MODULES

Fan Blade

Description (Cont.):

If replacement fan blades are required, different steps must be followed depending on the number of fan blades being replaced.

Replacing Four or Less Blades (Since Last Engine Test Cell Run)

- Make a record of the replaced fan blades by Serial Number (SN) and quantity.
- No change to N1 modifiers is required.

Replacing Five to Ten Blades (Since Last Engine Test Cell Run)

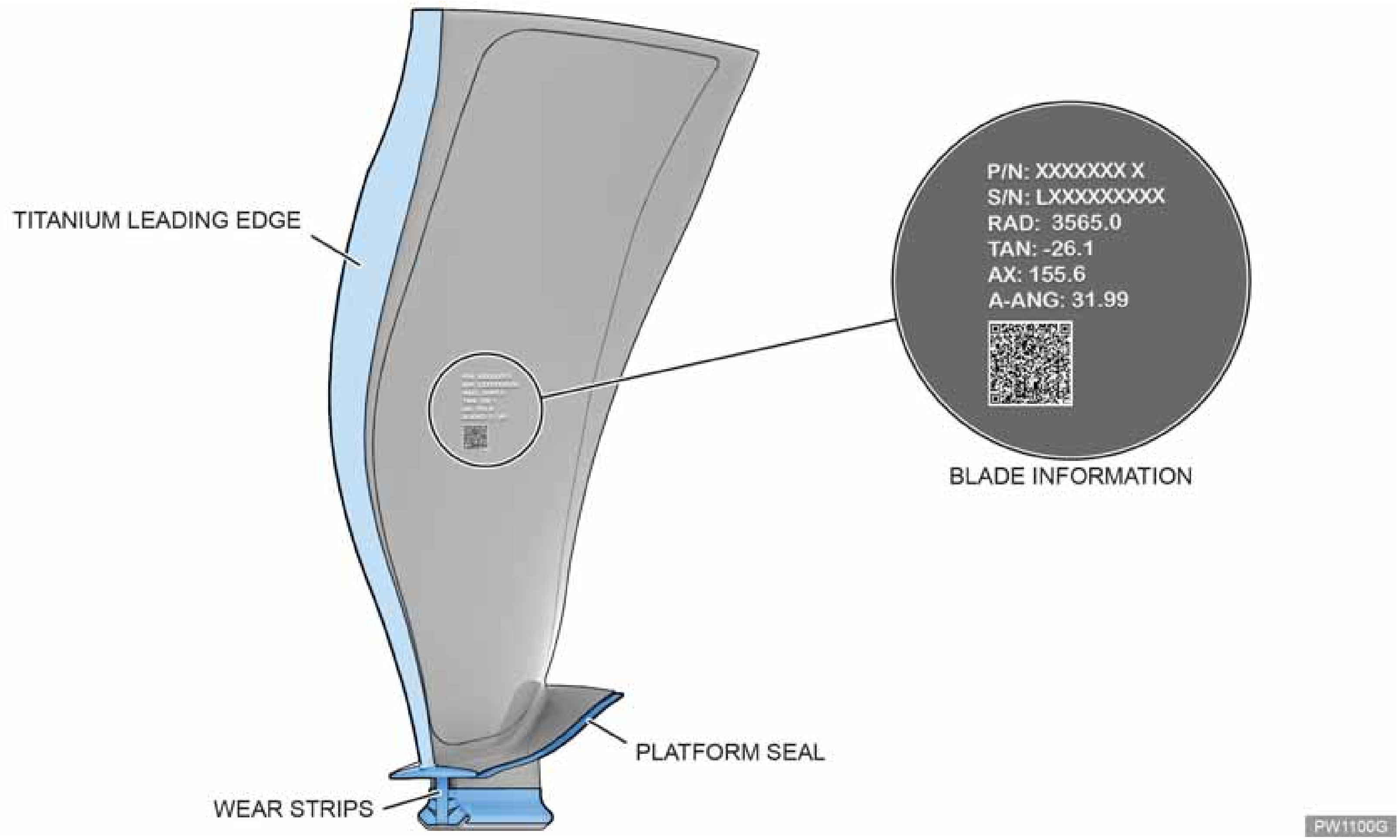
- Make a record of the replaced fan blades by SN and quantity.
- Reprogram the Data Storage Unit (DSU) using the Common Engine Software Loader (CESL) (PWA111515). From the drop-down menu, select “five to ten” fan blades to be replaced.
- The CESL software will automatically calculate the N1 modifiers again.

Replacing 11 to 20 Blades

- Make a record of the replaced fan blades by SN and quantity.
- Reprogram the DSU with the CESL. From the drop-down menu, select “11 to 20” fan blades to be replaced.
- The CESL software will automatically calculate the N1 modifiers again.

NOTE

When N1 modifiers are reduced, Exhaust Gas Temperature (EGT) margin loss will occur. EGT margin should be considered before deciding on a fan blade change plan.



FAN BLADE FEATURES

ENGINE MODULES

Fan Blade (Cont.)

Fan Blade Lock Removal and Installation Tool

The fan blade lock removal and installation tool PWA111529 is required to disengage the front blade lock ring from the fan hub. The tool is also used to install the blade lock ring.

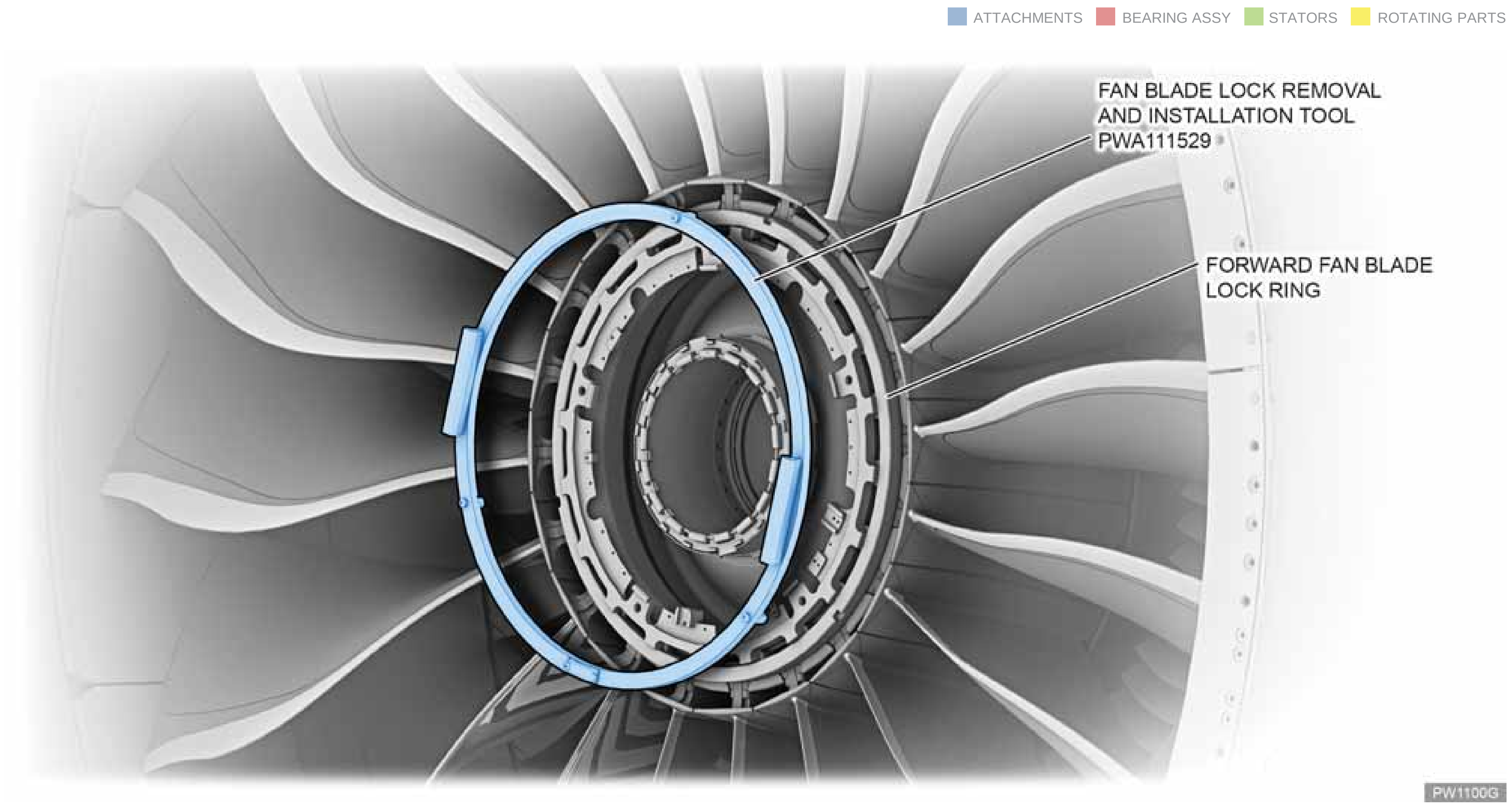
The puller is composed of a metal ring with two handles attached 180 degrees apart. Three lugs attached to the ring are spaced 120 degrees radial apart to align with three notches that are machined into the front blade lock ring.

Removal

Once the puller lugs are engaged to the blade lock notches, the tool is turned counterclockwise to remove the blade lock ring from the fan hub.

Installation

The tool is engaged to the blade lock, fitting with the lock onto the fan hub. The tool is then turned clockwise to engage the lock ring to the fan hub.



FAN BLADE LOCK RING TOOL

ENGINE MODULES

Fan Blade (Cont.)

No. 1 Fan Blade Slot Identification

The fan blade slot is identified by a marking on the No. 1 fan hub platforms. The No. 2 blade slot is also marked and will always be to the left (counterclockwise) of the No. 1 slot.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS

No. 1 FAN BLADE SLOT IDENTIFICATION

ENGINE MODULES (Cont.)

Fan Case Assembly

Purpose:

The Fan Case Assembly contains and directs the fan airstream, sending part of the air directly through the gaspath and the majority of air outside the gaspath as bypass air. The fan case also provides the structural link between the inlet cowl and the core engine.

In the event of 1st Stage fan blade failure, the fan case will contain the liberated blade.

Location:

The Fan Case Assembly is located between the inlet cowl and the Fan Intermediate Case (FIC).

Description:

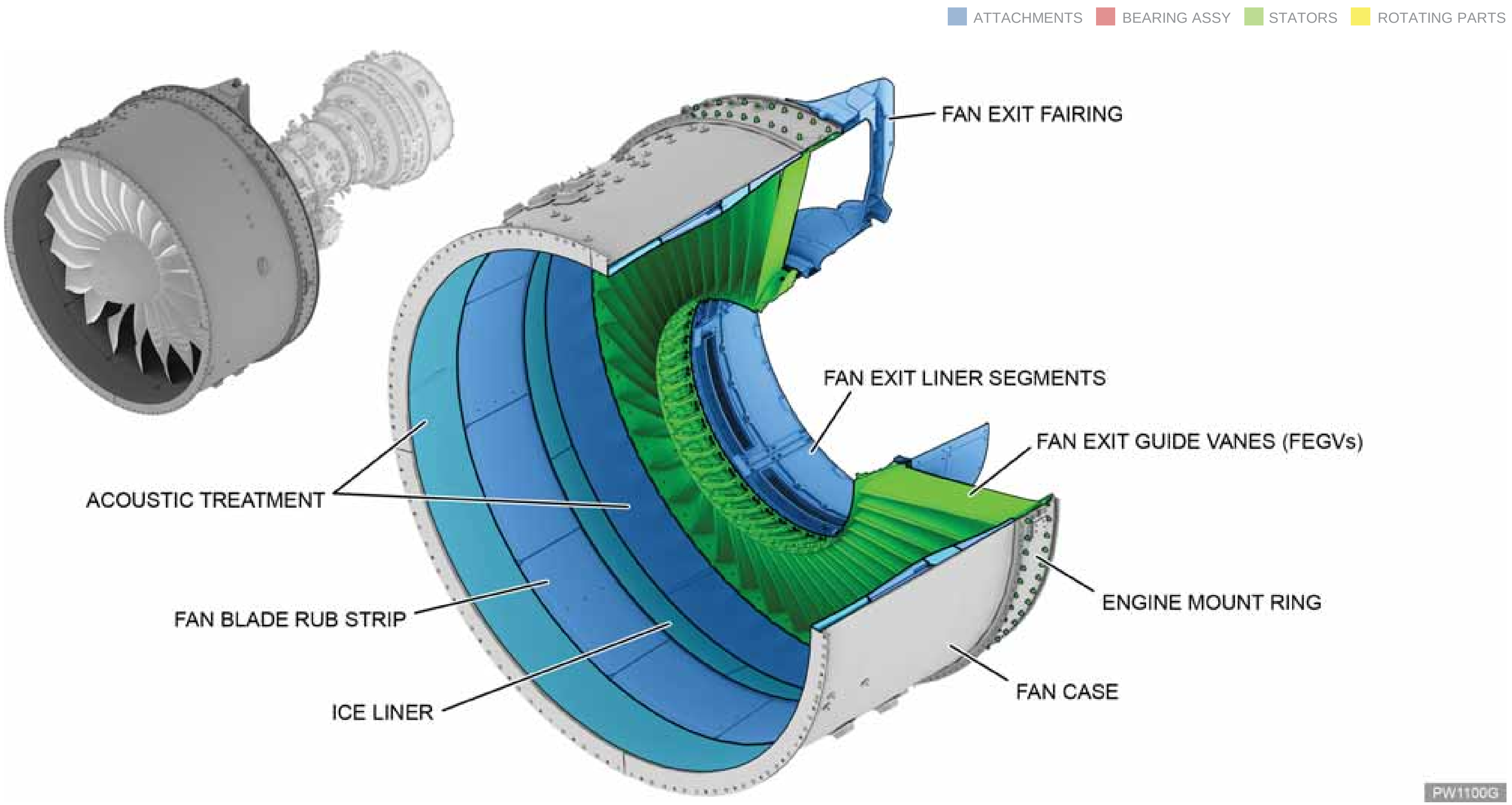
The Fan Case Assembly is made up of the fan case, Fan Exit Guide Vanes (FEGVs), fan exit liner segments, and fan exit fairing. The fan case is a one-piece composite case with an acoustically treated inner surface that decreases noise. A fan blade rub strip area protects fan blades from contact with the fan case.

An ice liner protects the case against ice shed by fan blades.

An aluminum support ring at the top rear of the fan case has a V-groove that provides alignment and support for the thrust reverser doors.

On the inner surface of the fan case, 48 hollow composite Fan Exit Guide Vanes extend to the Fan Intermediate Case. The stationary FEGVs straighten the fan air and also provide radial support between the FIC and the Fan Case Assembly. The Fan Exit Guide Vanes have titanium leading edges for protection.

A fan exit liner assembly goes around the outer area of the LPC. Louvers in these fan exit liner segments release 2.5 bleed air from the LPC into the fan stream at the correct angle.



FAN CASE ASSEMBLY (CUTAWAY VIEW)

ENGINE MODULES

Fan Case Assembly (Cont.)

Cartridge Liner Assembly

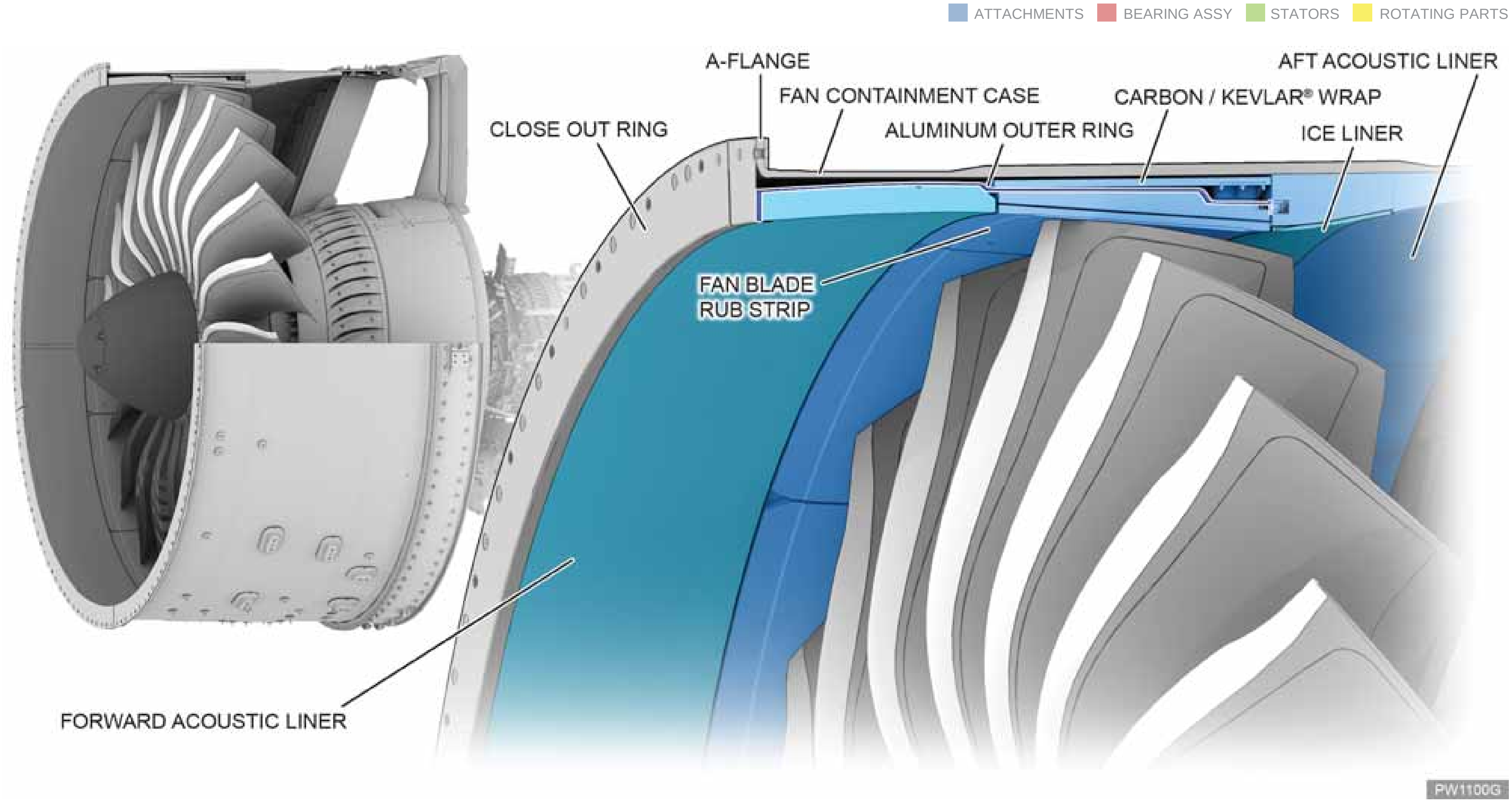
The cartridge liner assembly reduces fan noise and ensures that a consistent fan blade tip clearance is maintained. The assembly is composed of a forward acoustic liner and fan blade rub strip liners.

The forward acoustic liner is constructed of an aluminum/ honeycomb material that helps to reduce fan noise.

The fan blade rub strip liner features an abradable resin material bonded to its inner diameter. The strength and low resistance abradability of the resin material maintains a consistent fan blade tip clearance around the circumference of the fan rotor, improving engine performance.

The assembly is held in position at the aft end by seven torque blocks that provide circumferential support. At the forward end, a close-out ring is bonded to the forward face of the assembly and functions as an attachment flange.

The assembly is fastened to the nacelle inlet cowl by screws through the fan containment case at A Flange.



CARTRIDGE LINER ASSEMBLY

Safety Conditions

WARNING

REMOVE AND INSTALL ONLY ONE FAN EXIT GUIDE VANE AT A TIME. FAN EXIT GUIDE VANES ARE NECESSARY FOR ENGINE STRUCTURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

ENGINE MODULES (Cont.)

Fan Exit Guide Vane (FEGV)

Purpose:

LRU

Fan Exit Guide Vanes straighten and direct the fan discharge airstream. They supply structural support of flight and blade-out loads and also provide radial support of the engine.

Location:

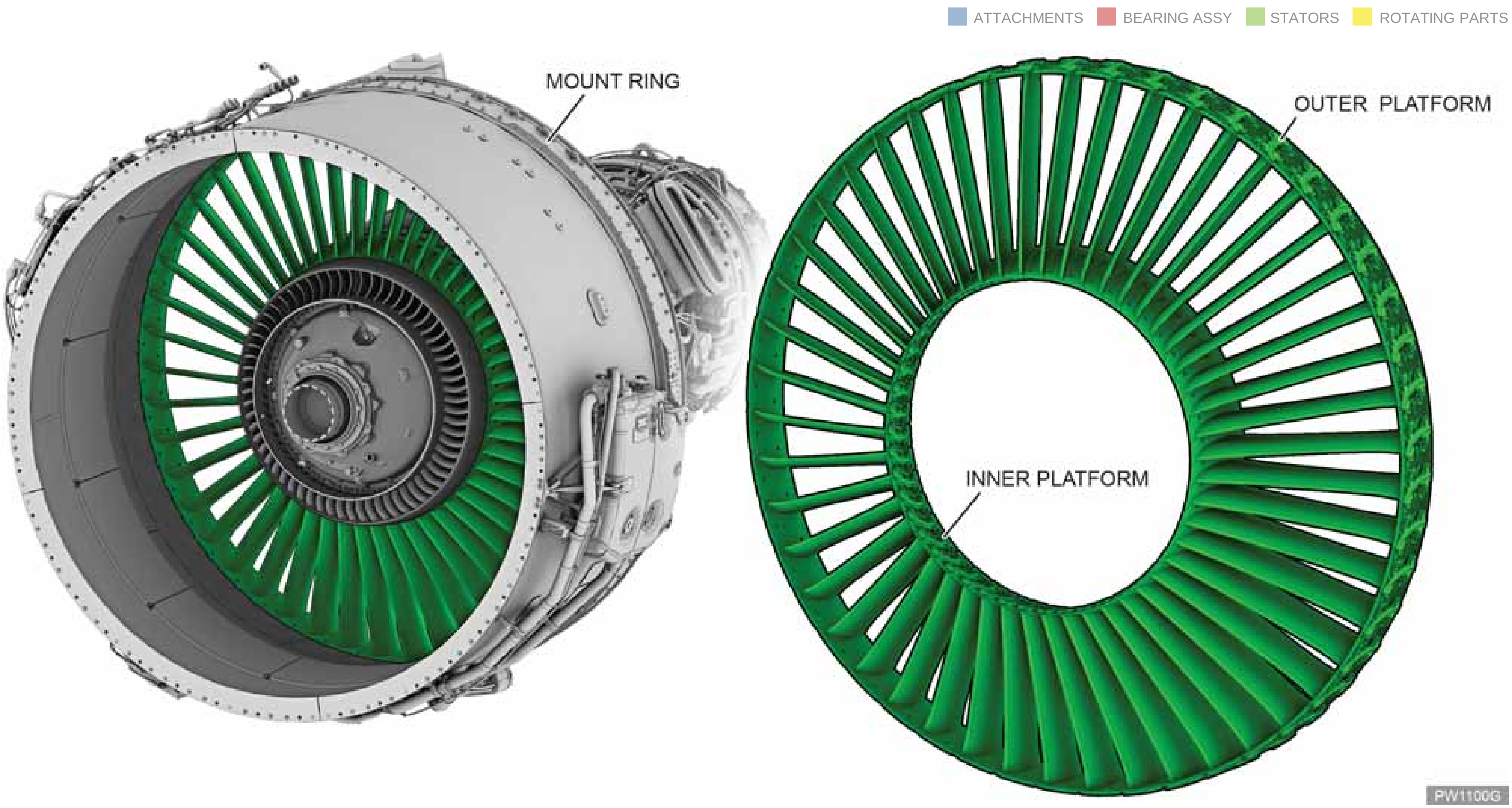
Fan Exit Guide Vanes are located aft of the fan blades.

Description:

A total of 48 composite FEGVs extend diagonally rearward from the outer diameter of the Fan Intermediate Case (FIC) to the inner diameter of the fan containment case. A titanium-strip is bonded to the leading edge of each FEGV to protect against bird strikes.

The FEGVs straighten fan bypass air and provide radial support for the Fan Case Assembly. The slanted assembly configuration helps to reduce fan noise.

Composite platforms at either end of each FEGV provide a smooth flowpath for fan bypass air.



FAN EXIT GUIDE VANE (FEGV)

ENGINE MODULES (Cont.)

Fan Drive Gear System (FDGS)

Purpose:

The Fan Drive Gear System allows the fan and low spool (LPC/LPT) to operate at different speeds, improving performance and efficiency, respectively.

Location:

The FDGS is located between the fan rotor and the Low Pressure Compressor (LPC) and is attached to the Fan Intermediate Case.

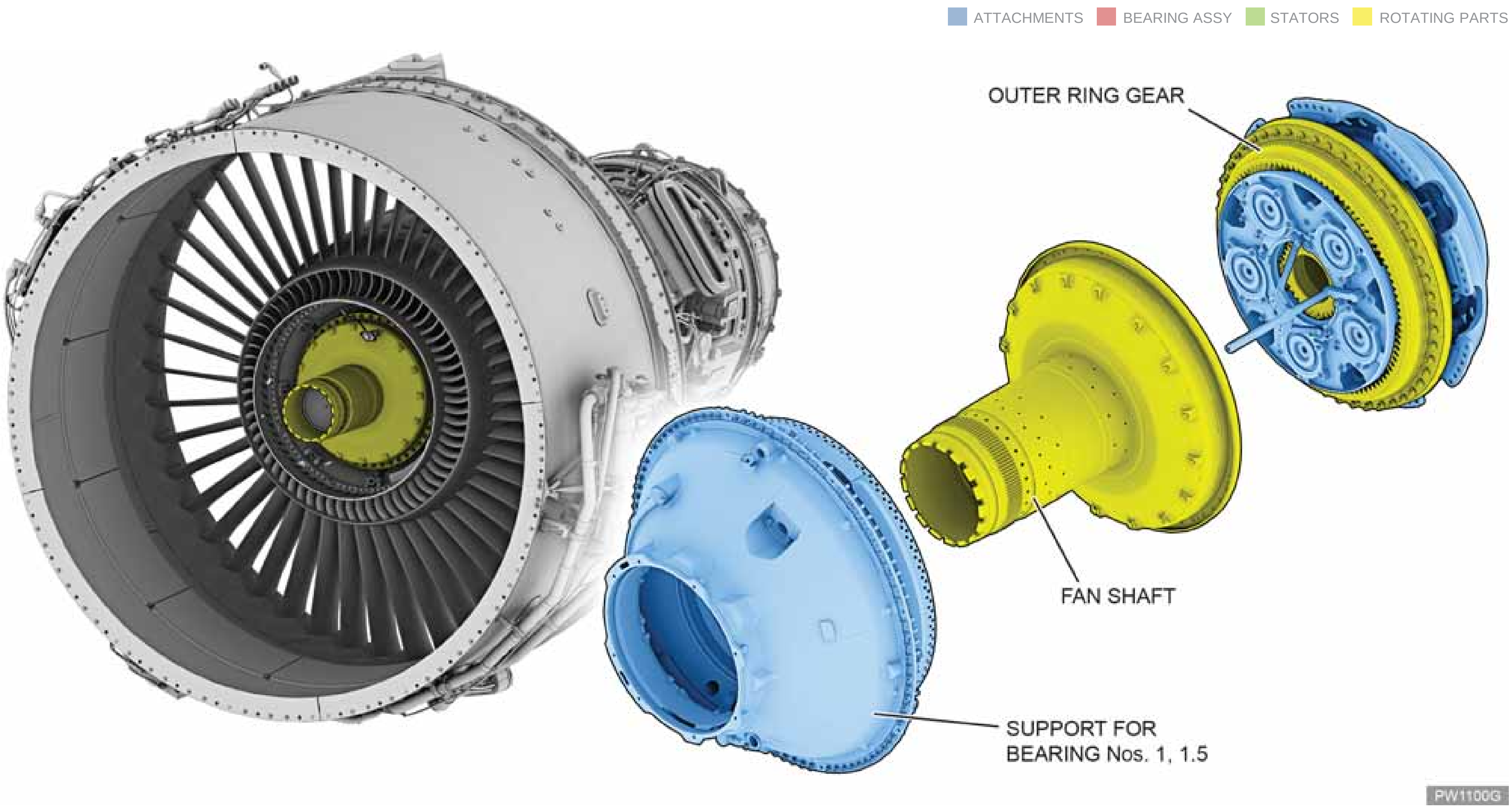
Description:

The FDGS is made up of a central sun gear surrounded by five star gears that are supported by journal bearings and an outer ring gear.

A torque frame and flex mount help align the FDGS input coupling and fan to the fan drive gear. This reduces extreme loads that can be transferred to the FDGS from the fan and LPC rotors, such as at takeoff.

The front of the FDGS is supported by bearings nos. 1 and 1.5.

The FDGS has an auxiliary oil supply to lubricate the journal bearings during a negative g-force or windmill event that would affect normal oil flow. The auxiliary system uses a Journal Oil Shuttle Valve (JOSV) and a dual-stage fan pump during these conditions to supply oil to protect the journal bearings.



FAN DRIVE GEAR SYSTEM (FDGS) – EXTERNAL VIEW

ENGINE MODULES

Fan Drive Gear System (FDGS) (Cont.)

Operation:

The geared technology of the PW1100G-JM allows the fan and low rotor to operate at different speeds. Energy from the N1 rotor is sent through the gears of the FDGS, slowing output to the fan. The process alters the normal 1:1 turning ratio to 3:1, or three turns of the N1 rotor for a single revolution of the fan.

1. The fan drive gear is a star gear reduction unit that takes the torque from the low spool (LPC/LPT), and uses it, through the fan drive gear coupler, to turn a sun gear.

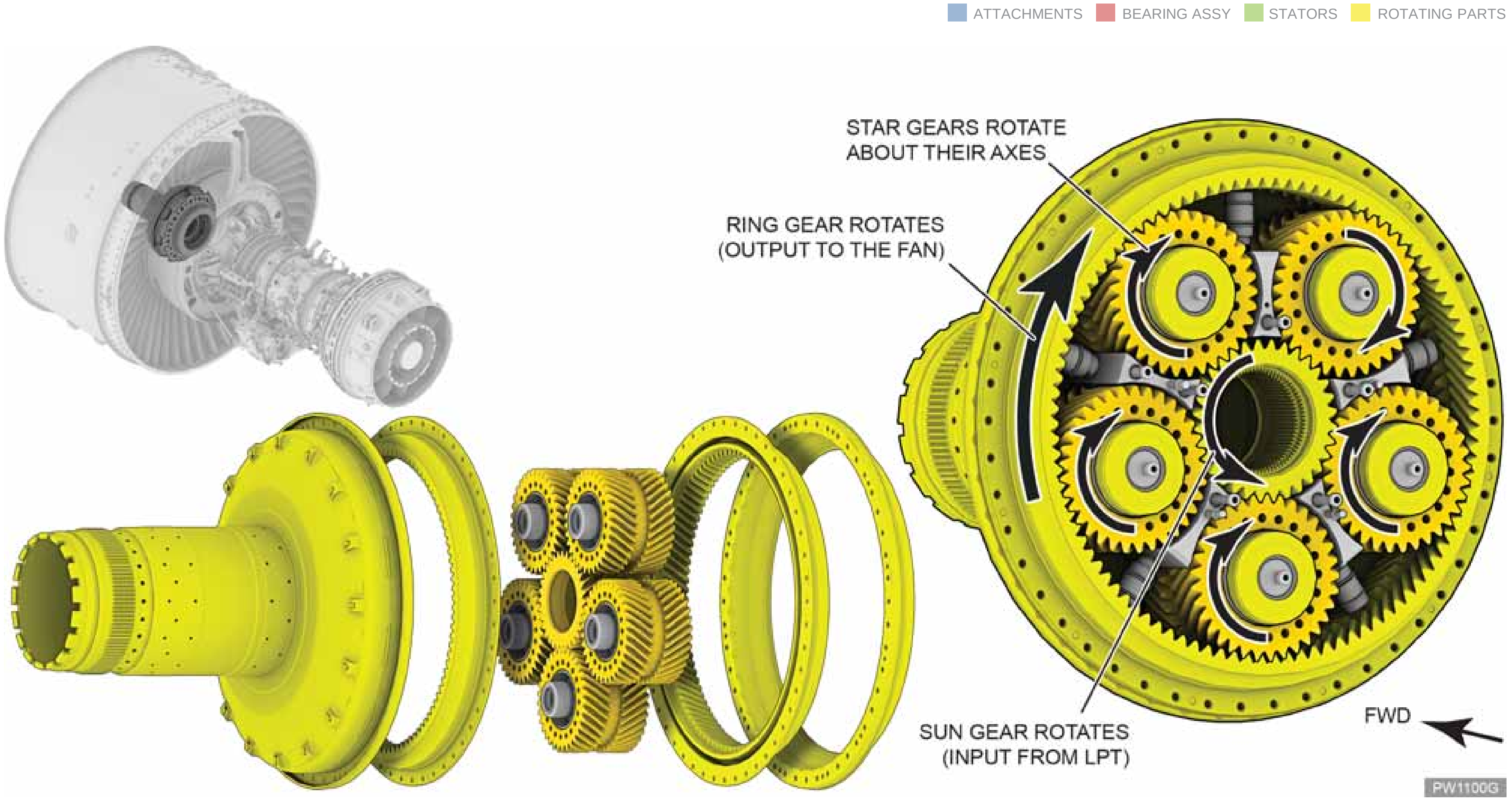
2. The sun gear then turns the five star gears against the outer ring gear, which is connected to the fan hub of the fan shaft. The ratio of LPC to fan hub speed is approximately 3:1.

3. The star gears and the carrier to which they are attached do not move around the sun gear. The sun gear engages the star gears, moving them in a direction that causes the outer ring gear and fan to turn in the opposite direction from the sun gear and LPC/LPT, at a slower speed. This design allows for lower fan speeds and higher LPC/LPT speed, increasing compressor efficiency.

KEY CONCEPT

The 3:1 turning ratio produced by the FDGS brings these heightened efficiencies:

- propulsive efficiency increases 20 percent
- fuel consumption decreases at least 16 percent
- nitrous oxide emission decreases at least 50 percent
- noise level decreases 20 decibels.



FAN DRIVE GEAR SYSTEM (FDGS) – INTERNAL VIEWS

ENGINE MODULES (Cont.)

Fan Intermediate Case (FIC)

Purpose:

The Fan Intermediate Case module provides support for bearing nos. 1 and 1.5, and for the Fan Drive Gear System. The FIC supports and contains the No. 2 Bearing assembly located behind it and also supports the fan case.

Location:

The FIC is located between the fan rotor and the Low Pressure Compressor.

Description:

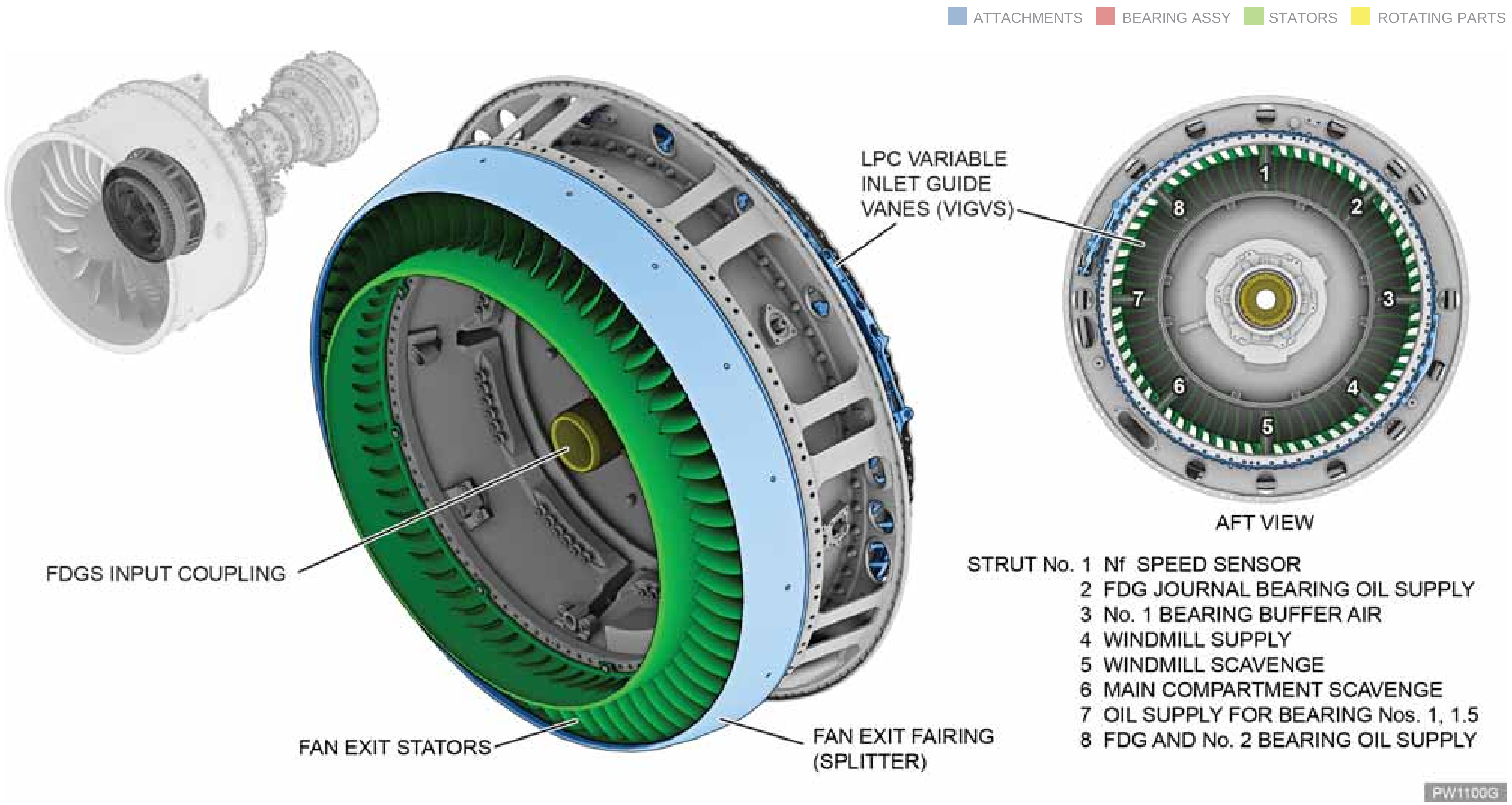
The FIC is made up of the fan exit stator and fairing, the No. 2 Bearing seal/support assembly, the FDGS input coupling, and LPC Variable Inlet Guide Vanes (VIGVs). The VIGVs direct fan airflow into the Low Pressure Compressor at the correct angle. A fan exit fairing smooths the airflow into and around the fan exit stator.

The EEC will adjust the VIGVs for varying engine operating conditions.

The No. 2 Bearing is an oil-damped ball bearing that holds the LPC rotor axially and radially.

Eight FIC struts provide structural support and pathways for oil supply, oil scavenge, and buffer air to the FDGS and bearing nos. 1, 1.5 and 2.

LPC VIGVs are attached to the Fan Intermediate Case.



FAN INTERMEDIATE CASE (FIC)

ENGINE MODULES (Cont.)

Fan Exit Fairing (Splitter)

Purpose: LRU PMT

The fan exit fairing (splitter) allows for smooth, efficient flow of bypass and primary air. It also covers and protects the outer attachment flange of the fan exit stator.

Location:

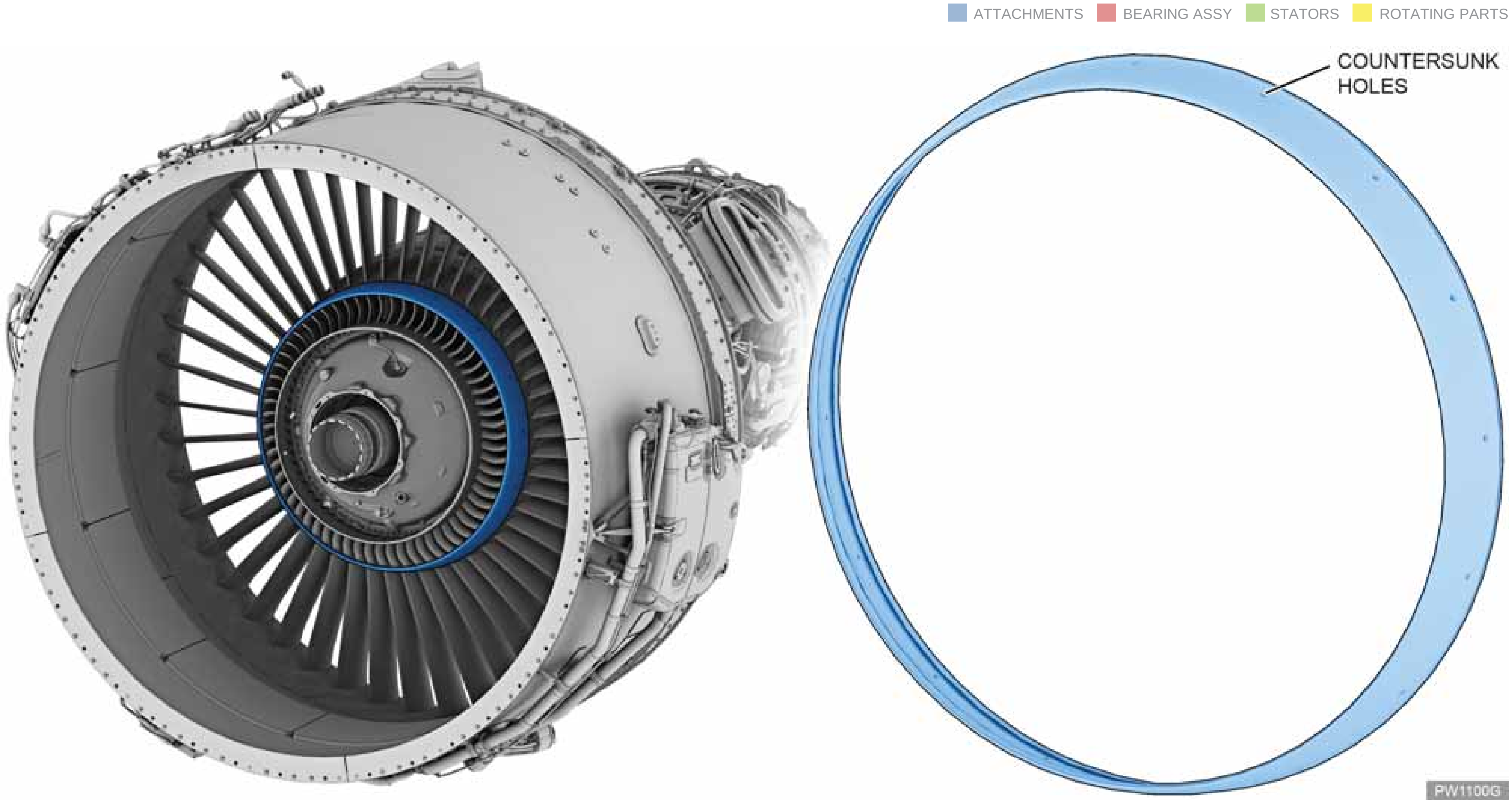
The fan exit fairing is located aft of the fan blades.

Description:

The fairing is made of a lightweight material and is attached with countersunk screws to the Fan Intermediate Case.

Operation:

The fairing provides a transitional surface where the fan air divides into bypass and primary airflow.



ENGINE MODULES – FAN EXIT FAIRING (SPLITTER)

ENGINE MODULES (Cont.)

Low Pressure Compressor (LPC)

Purpose:

The Low Pressure Compressor increases the pressure of gaspath air from the fan and sends it to the Compressor Intermediate Case and the High Pressure Compressor.

Location:

The LPC is located to the rear of the Fan Intermediate Case.

Description:

The LPC is connected at its front to the fan rotor through the Fan Drive Gear System (FDGS).

The LPC is made up of three Integrally Bladed Rotors (IBRs) and two stator stages. The 3rd Stage stator is part of the Compressor Intermediate Case Assembly.

Tie rods attach the LPC rotor hub to the 1st, 2nd and 3rd stage rotors. The LPT shaft splines into the LPC rotor hub, and the No. 2 Bearing supports the LPC and the front of the LPT shaft.

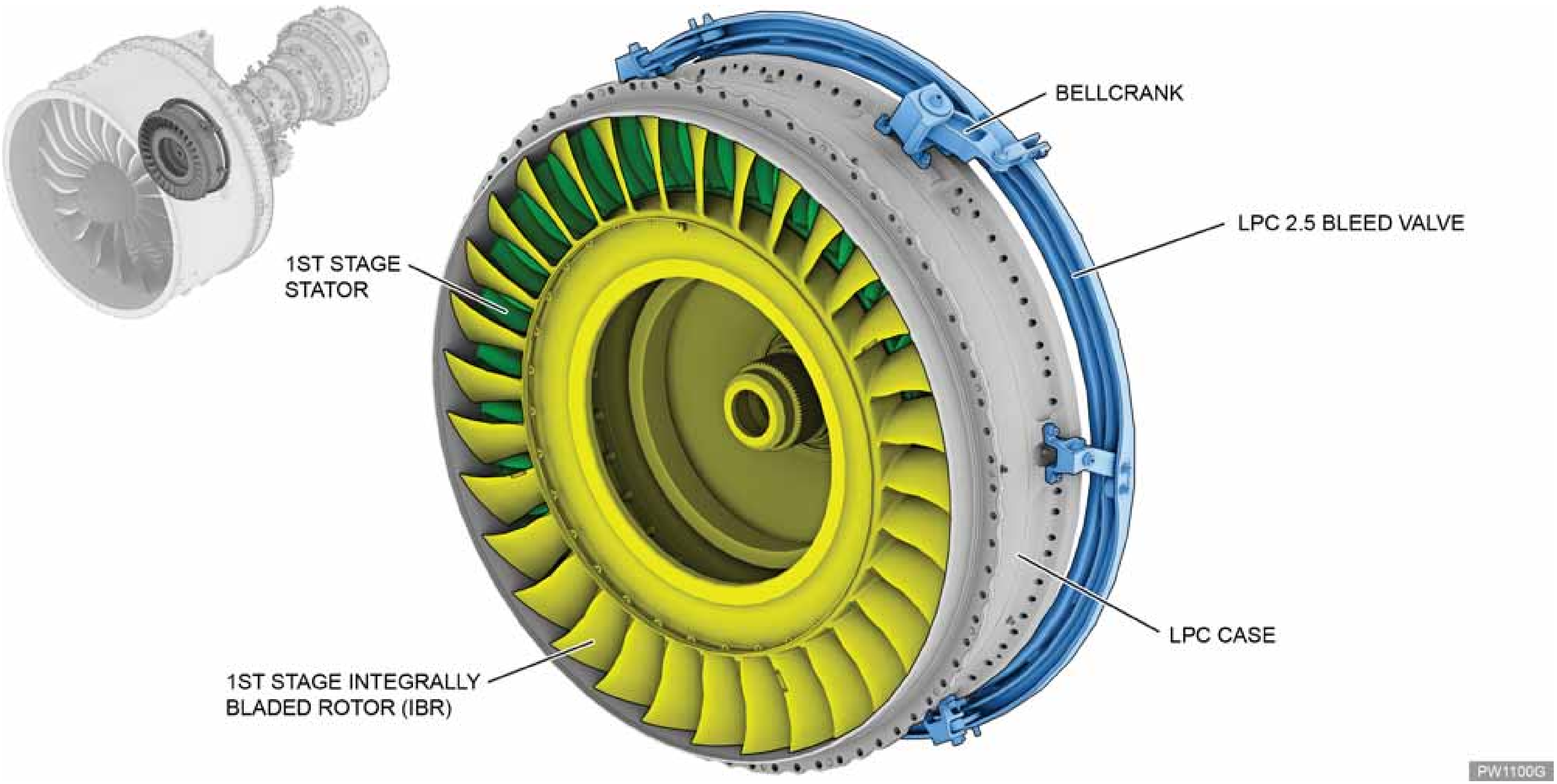
An annular 2.5 bleed valve at the rear of the LPC is controlled by an actuator, rod, and bellcrank linkage. The bleed valve releases air from the LPC, enhancing stability and efficiency.

Access ports for LPC borescope inspection are found at 9:00 viewed from the aft end of the engine looking forward.

Air from the rear of the Fan Intermediate Case goes through the LPC Stator Vane Assembly Variable Inlet Guide Vanes and into the three-stage compressor.

The LPC rotates in a counterclockwise direction as viewed aft.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



LOW PRESSURE COMPRESSOR (LPC)

ENGINE MODULES (Cont.)

Compressor Intermediate Case (CIC)

Purpose:

The Compressor Intermediate Case contains and provides a flow path for engine core airflow coming from the LPC to the HPC. In addition it supports the No. 3 Bearing/bevel gear shaft and the gearbox drive bevel gear assemblies.

Location:

The CIC is the transition case between the low pressure and high pressure compressors.

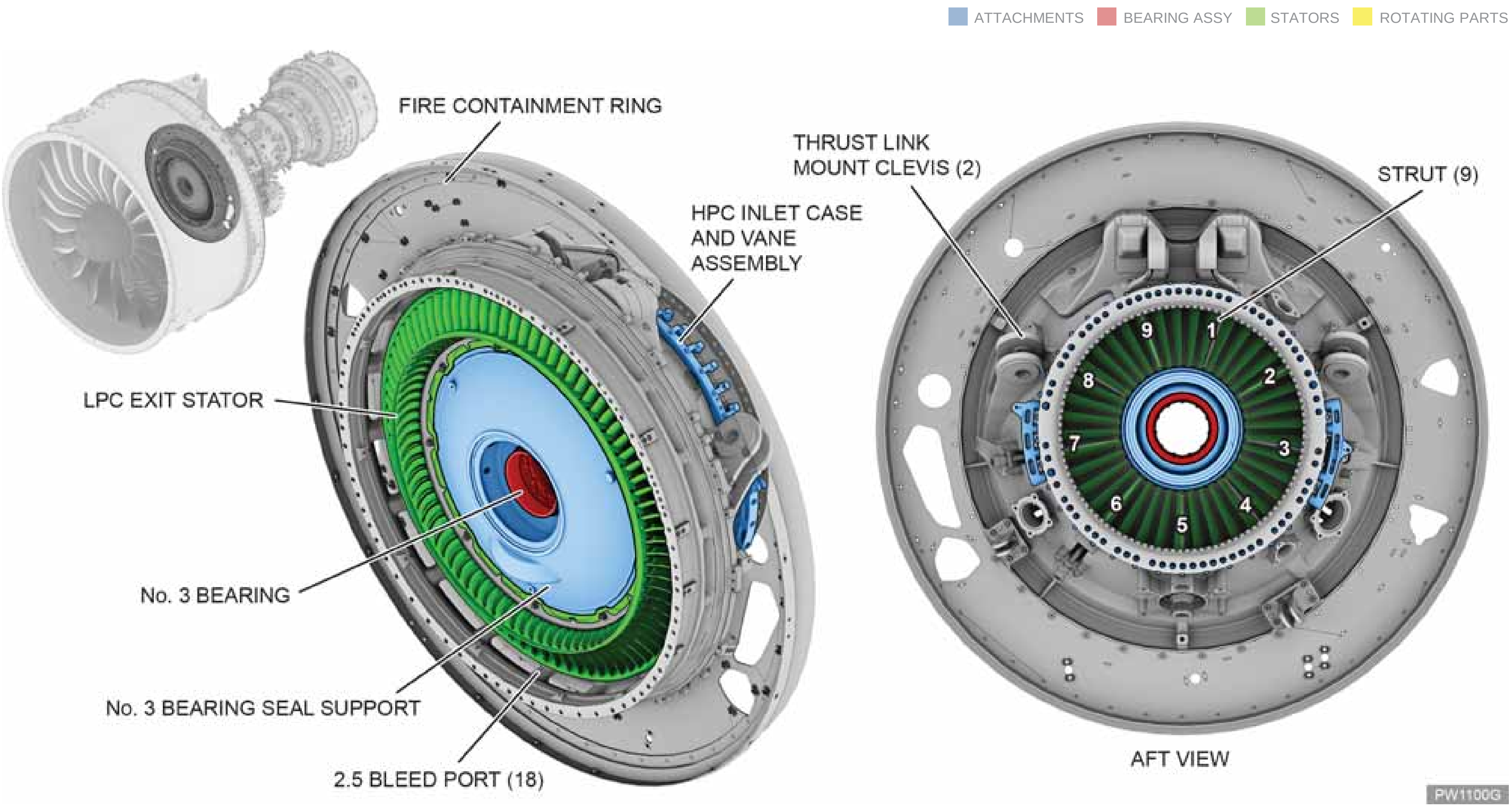
Description:

The CIC contains two primary engine mounts, a redundant engine mount, and two thrust link mounts. The CIC is bounded by the LPC exit stator at the front and by the HPC Variable Inlet Guide Vane Assembly at the rear. Ports for 2.5 bleed air are located at the front of the CIC.

The CIC contains No. 3 Bearing seals and the oil pressure and oil scavenge tubes that are routed through the case struts. Case struts are also used to route buffer supply air to bearing nos. 2 and 3, and to route breather air from the No. 3 Bearing and the tower shaft that drives the Angle Gearbox.

On the aft side of the CIC, two thrust link mount clevises and a fire containment ring separate the core nacelle from the LPC. The ring also supports the thrust reverser Inner Fixed Structure.

Strut	Pathway
1	N/A
2	Forward buffer supply
3	Rear buffer supply/N1 sensor
4	Rear buffer supply
5	No. 3 Bearing compartment oil scavenge
6	• No. 3 Bearing main oil supply • No. 3 Bearing dampener oil supply
7	Tower shaft oil supply
8	Compartment breather vent
9	N/A



COMPRESSOR INTERMEDIATE CASE (CIC)

ENGINE MODULES (Cont.)

High Pressure Compressor (HPC)

Purpose:

The High Pressure Compressor increases the temperature and pressure of primary gaspath air before sending it to the diffuser and combustor.

Location:

The HPC is located between the CIC and the diffuser and combustor.

Description:

The HPC has eight stages, in contrast to traditional turbofan engine technology that requires 10 to 17 stages. The lower count is due to efficiencies produced by the FDGS. The eight rotor stages are composed of Integrally Bladed Rotors (IBRs). Rotor stages are held together with a tie shaft that connects the HPC front hub and rear hub, and extends rearward to the High Pressure Turbine.

The HPC is held radially and axially at the front by the No. 3 Bearing, which is a ball bearing, and is held radially at the rear by the No. 4 Bearing, which is a roller bearing. Both bearings are oil damped to reduce wear and to reduce HPC rotor vibration.

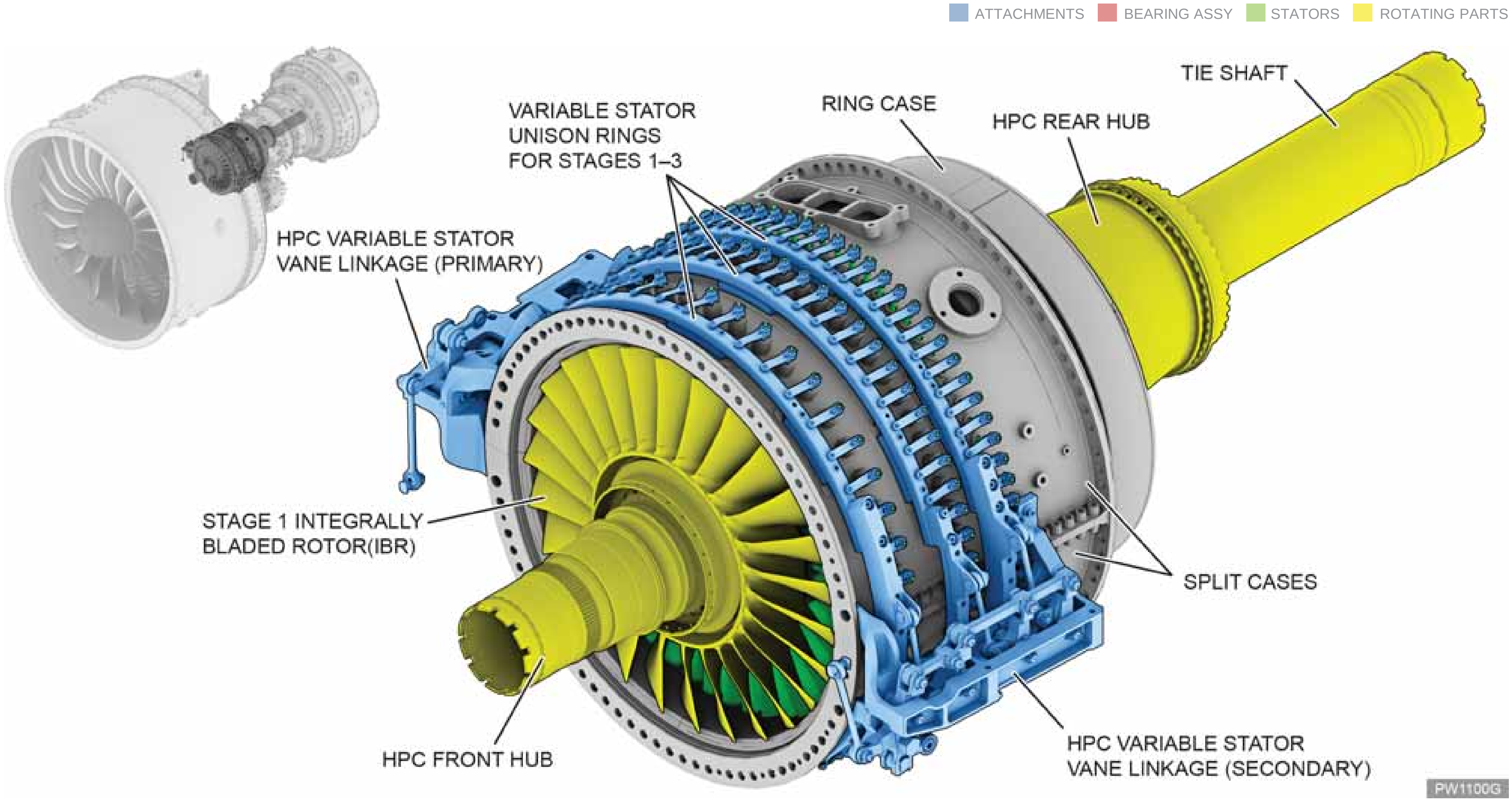
The Variable Inlet Guide Vanes (VIGVs) and the first three stages of the HPC stator vanes are variable for optimal airflow. The Variable Stator Vanes (VSVs) are connected by a series of unison rings and linkages to primary and secondary actuators. Remaining stators, stages 4 through 7, are fixed, each vane installed in ring cases that extend inward and seal against a stator rub surface on the adjacent rotor. The rub surface prevents air from leaking past the end of the vane. The 8th Stage stator (also an Exit Guide Vane) has a cast, one-piece design.

Operation:

The HPC supplies air to the airframe Pneumatic System and various engine systems using 3rd, 6th, and 8th stage air. Eighth Stage is also referred to as HPC discharge bleed air at Station 3.

The HPC is powered by the HPT. Engine bleed air from Station 2.5 buffer air and the HPC Stage 7 rotor cools the HPC internally.

Five borescope ports at the rear of each vane stage on the right side of the engine are used for inspection or repair of airfoils.



HIGH PRESSURE COMPRESSOR (HPC)

ENGINE MODULES (Cont.)

Diffuser/Combustor

Purpose:

The diffuser straightens and slows compressed air from the HPC. It reduces the velocity of the air while increasing its static pressure to permit proper mixing and combustion of the fuel. The diffuser also offers structural support to the HPC and HPT cases.

The combustor provides a contained space where the fuel and air mix and are ignited and burned to produce energy to turn the turbines.

Location:

The diffuser and combustor are located between the HPC and HPT.

Description:

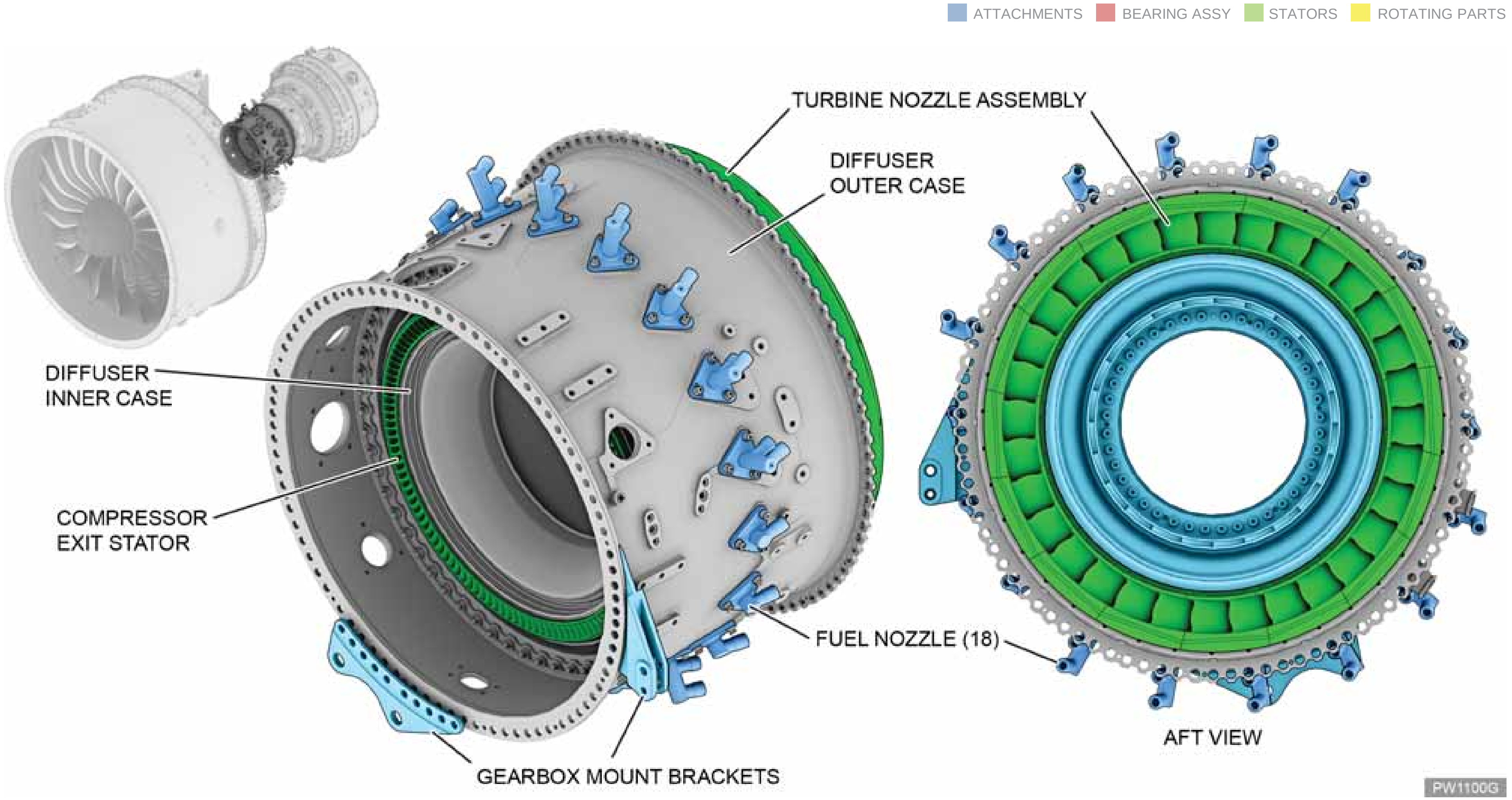
The diffuser case assembly houses all of the parts of the diffuser, combustion, and turbine nozzle assemblies. It also supports the rear of the HPC inner case and provides an outer case for HPC stages 7 and 8.

The diffuser/combustor includes the components shown below.

- Diffuser case (inner and outer)
- Compressor exit stator assembly
- Fuel nozzles (18)
- Fuel supply manifolds
- Igniter plugs (2)
- Combustion chamber assembly and turbine nozzle assembly
- Main Gearbox mount brackets (2)

Operation:

1. Within the combustion chamber, fuel nozzles supply metered fuel. The mix of fuel and air is ignited and burned, causing the air to expand and accelerate rearward.
2. Turbine nozzle guide vanes direct the high-temperature, high-velocity gases out of the combustion chamber to drive the turbines.



DIFFUSER CASE ASSEMBLY

ENGINE MODULES

Diffuser/Combustor (Cont.)

Combustion Chamber Assembly

The combustion chamber provides a contained space where the fuel and air mix and are ignited and burned to produce energy.

Location:

The assembly is located within the diffuser case.

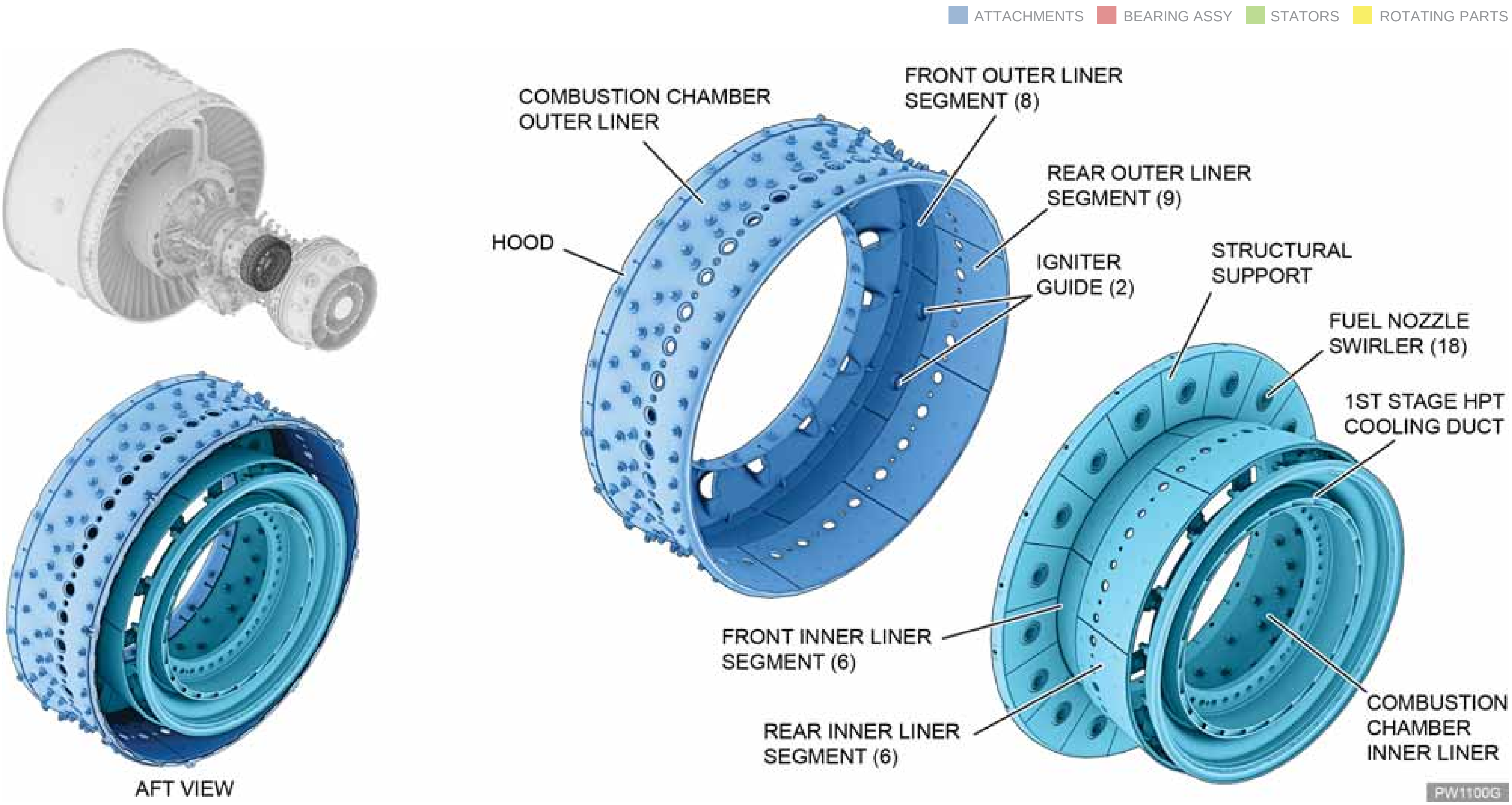
Description:

The combustion chamber consists of inner and outer chamber liner assemblies, a bulkhead, and a hood assembly.

The inner and outer liners have replaceable, coated segments that are bolted to a sheet metal liner referred to as a floatwall design. Segments have hundreds of cooling holes for durability. Inner and outer segments have rows of dilution holes that provide air to reduce the formation of NOx emissions during combustion.

The bulkhead has fuel nozzle guides and swirlers, and provides separation of the HPC exit air and combustion gases.

The combustion chamber liner hood distributes the incoming HPC discharge air to both the inner and outer sections of the chamber. Chamber liners and the hood are bolted to the bulkhead.



COMBUSTION CHAMBER ASSEMBLY

ENGINE MODULES

Diffuser/Combustor (Cont.)

Turbine Nozzle Assembly

Purpose:

The turbine nozzle assembly provides the flowpath for combustion gases to the 1st Stage turbine blades.

Location:

The assembly is located between the combustion chamber and the HPT.

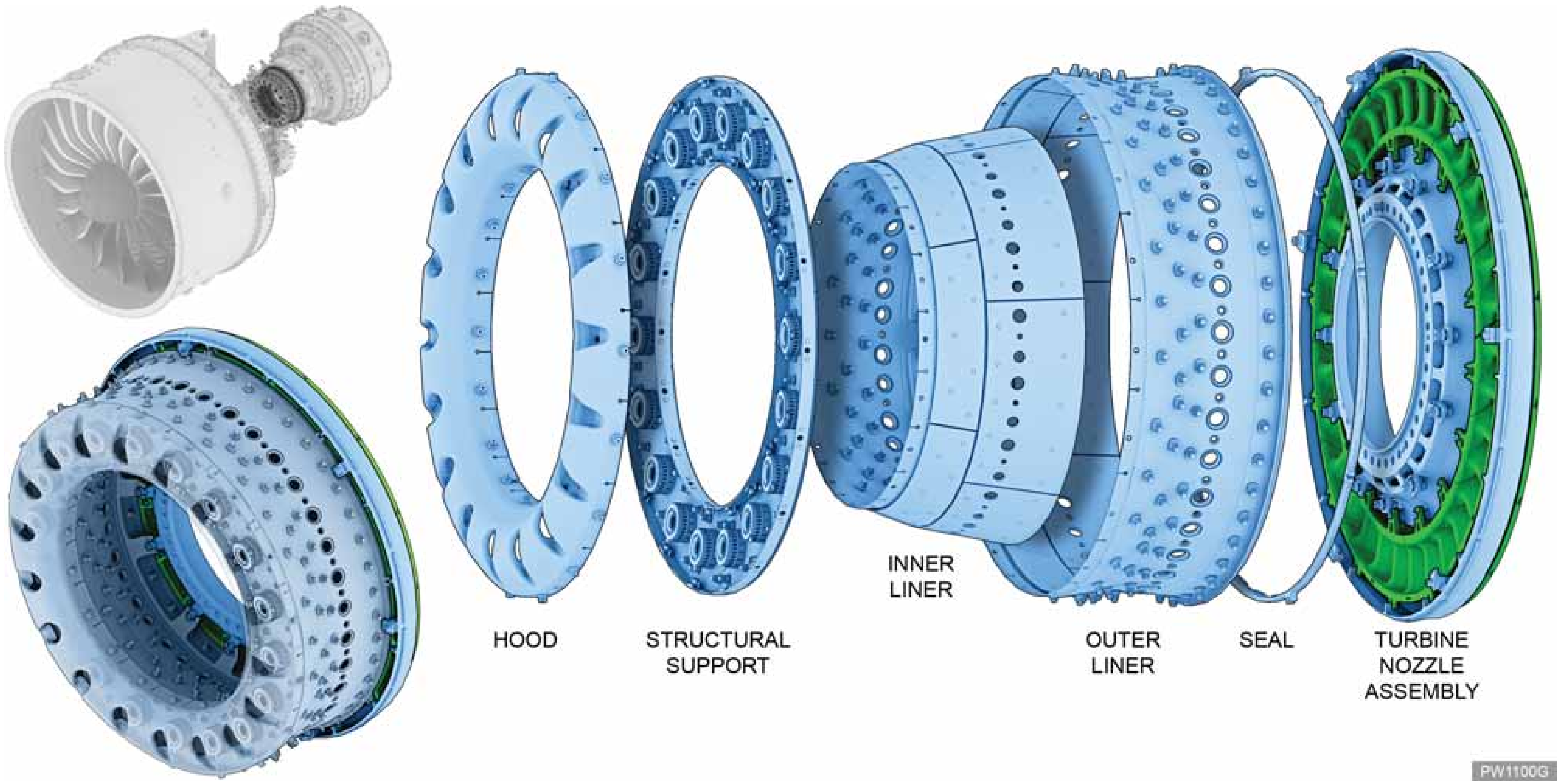
Description:

The assembly incorporates 32 air-cooled guide vanes assembled around the 1st Stage turbine vane (nozzle) support.

Operation:

The ring of vanes changes the direction of the hot gases to provide optimal angle, pressure, and flow to the 1st Stage turbine blades.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



COMBUSTION CHAMBER LINERS AND TURBINE NOZZLE ASSEMBLY

ENGINE MODULES (Cont.)

High Pressure Turbine (HPT)

Purpose:

The High Pressure Turbine provides the rotational force to drive the High Pressure Compressor (HPC) by extracting energy from the hot combustion gases.

Location:

The HPT is located between the combustor and the Turbine Intermediate Case.

Description:

The HPT is made up of two assemblies: a two-stage rotor, and a turbine case and vanes.

Rotor Assembly

Each stage of the two-stage rotor assembly has 44 blades installed to firtree slots in the rotor disk. A rotating knife-edge seal is located at the front and rear of the rotor to control air leakage. The HPT blades have a thermal barrier coating and are internally cooled to enhance ability to withstand high temperatures.

At the front hub of the 1st Stage turbine rotor a coupling meshes with the HPC rear hub, allowing the HPT to drive the HPC rotor assembly. A bore is machined in the aft of the inner diameter of the 2nd Stage hub, providing a tight fit with the tie-shaft to help support the HPT rotor assembly.

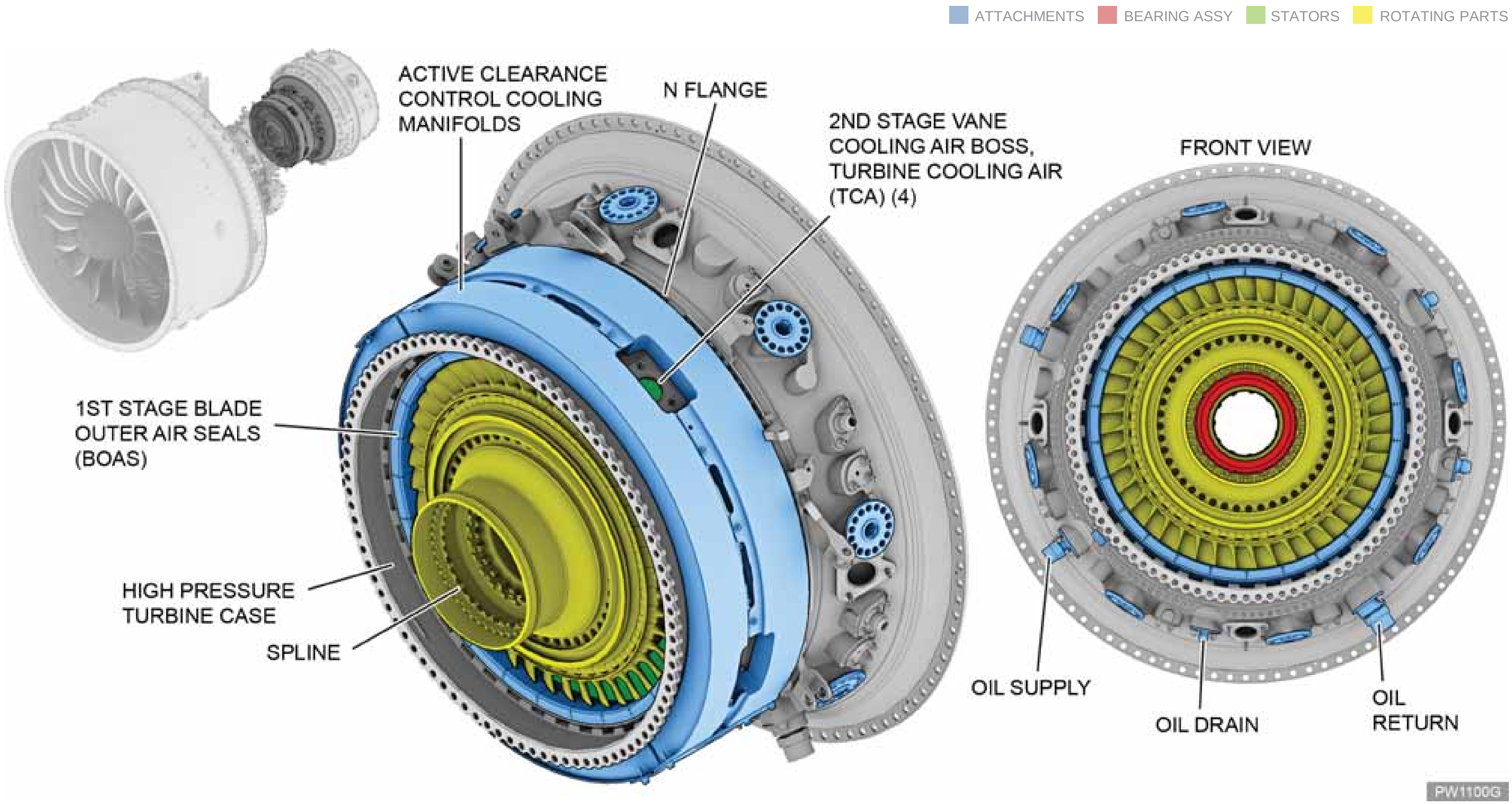
The two hubs are connected by intermeshing castellations. An HPT retaining nut installed at the aft end of the tie-shaft provides axial retention of the HPT rotor assembly. The HPT rotor is supported radially by the No. 4 Bearing.

Turbine Case and Vanes

The HPT case supports the 2nd Stage vanes positioned between the turbine rotors. The vanes direct from the 1st Stage to the 2nd Stage at the optimal angle and pressure.

The 2nd Stage vanes are hollow to allow internal cooling of the vanes. Temperatures are kept as low as possible by the Turbine Cooling Air (TCA) system that supplies cooling air through the cooling air bosses in the HPT case.

Blade Outer Air Seals (BOAS) are installed to the HPT case for both 1st and 2nd stage blades. BOAS provide a sealing surface for the blade tips that reduces air leakage and improves performance. The HPT case features Active Clearance Control (ACC) cooling manifolds around the outside to control blade tip clearance.



HIGH PRESSURE TURBINE (HPT)

ENGINE MODULES (Cont.)

Turbine Intermediate Case (TIC)

Purpose:

The Turbine Intermediate Case directs the HPT gaspath airflow to align with the counter-rotating LPT, and supports the No. 4 Bearing.

Location:

The TIC is integrated within the HPT Assembly.

Description:

The module houses the Turbine Stator Assembly and the No. 4 Roller Bearing Assembly.

Turbine Stator Assembly

The Turbine Stator Assembly between the inner and outer cases has 16 stator vanes. Vanes have an airfoil contour that turns the HPT gaspath airflow to align with the LPT.

The TIC uses eight support rods to connect the inner and outer cases through bosses in the stator vanes.

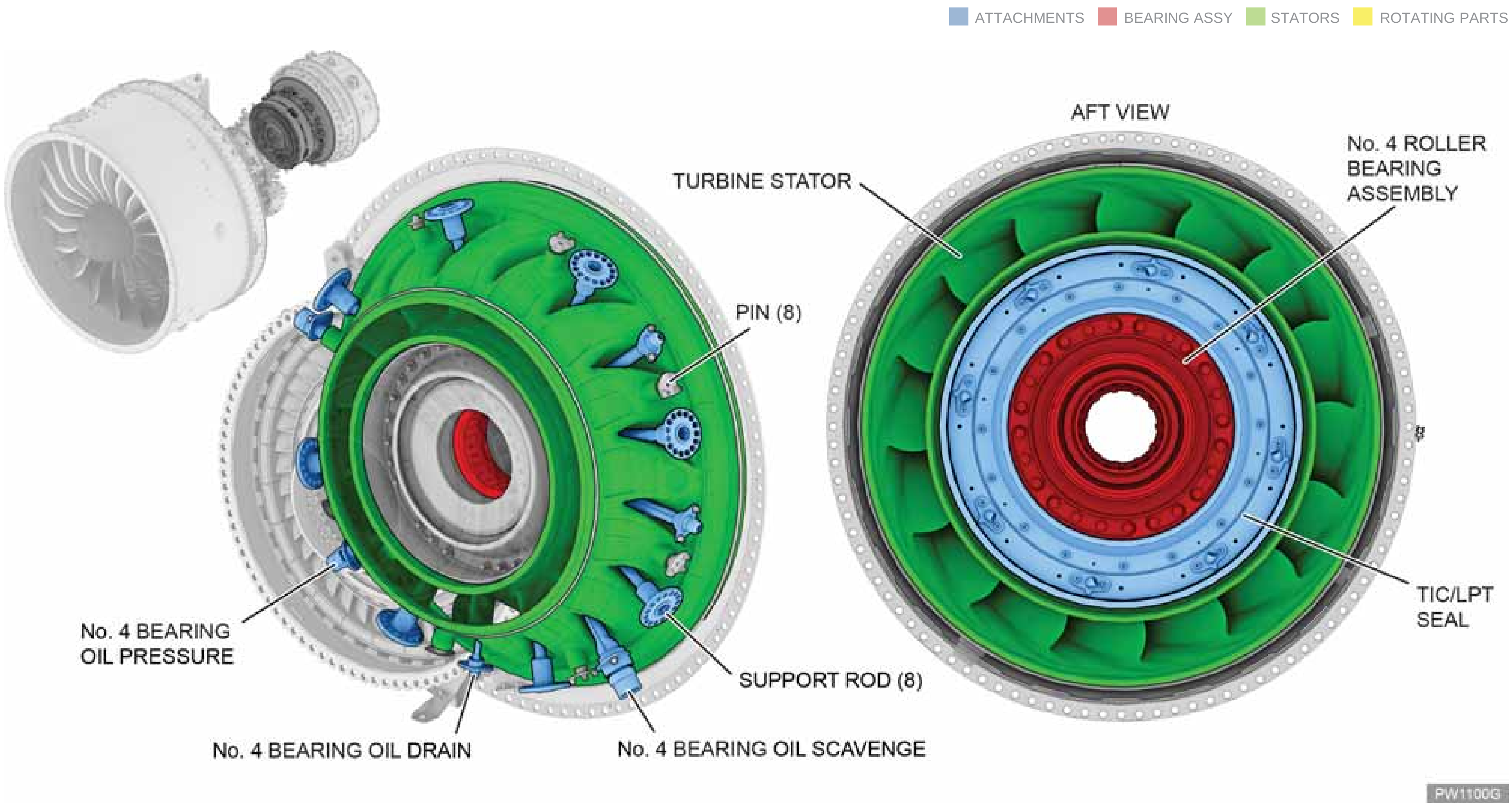
Pressure, scavenge and drain oil tubes from the No. 4 Bearing compartment go through three of the remaining vane bosses. Stator vanes protect the support rods and tubes from high gaspath temperatures.

No. 4 Roller Bearing Assembly

The No. 4 Roller Bearing Assembly supports the rear of the HPT rotor and contains the No. 4 Bearing support, attached to the inner case. The oil-damped assembly maintains a pressurized oil film around the bearing outer race in order to absorb rotor vibration.

No. 4 Bearing compartment oil leakage is controlled by carbon seals at the front and rear of the compartment, and by buffer sealing air supplied by a buffer air tube. Buffer air cools the compartment and prevents oil from *coking*, or heating to the point of solidifying.

The stator vanes are positioned circumferentially by eight centering pins that are inserted into bosses on the outer diameter of every other vane. Each centering pin is attached to the HPT case with three bolts. At one location, the centering pin is integrated with the TIC borescope plug.



TURBINE INTERMEDIATE CASE (TIC)

ENGINE MODULES (Cont.)

Low Pressure Turbine (LPT)

Purpose:

The Low Pressure Turbine provides rotational driving force for the Low Pressure Compressor and Fan Drive Gear System by extracting energy from the hot combustion gases.

Location:

The LPT is located between the TIC and the Turbine Exhaust Case.

Description:

The LPT consists of these components:

- three-stage rotor assembly
- LPT shaft
- 2nd and 3rd stage turbine vanes
- two borescope access ports
- turbine case assembly.

Viewed from the rear, the LPT rotates in a counterclockwise direction, the opposite of the HPT.

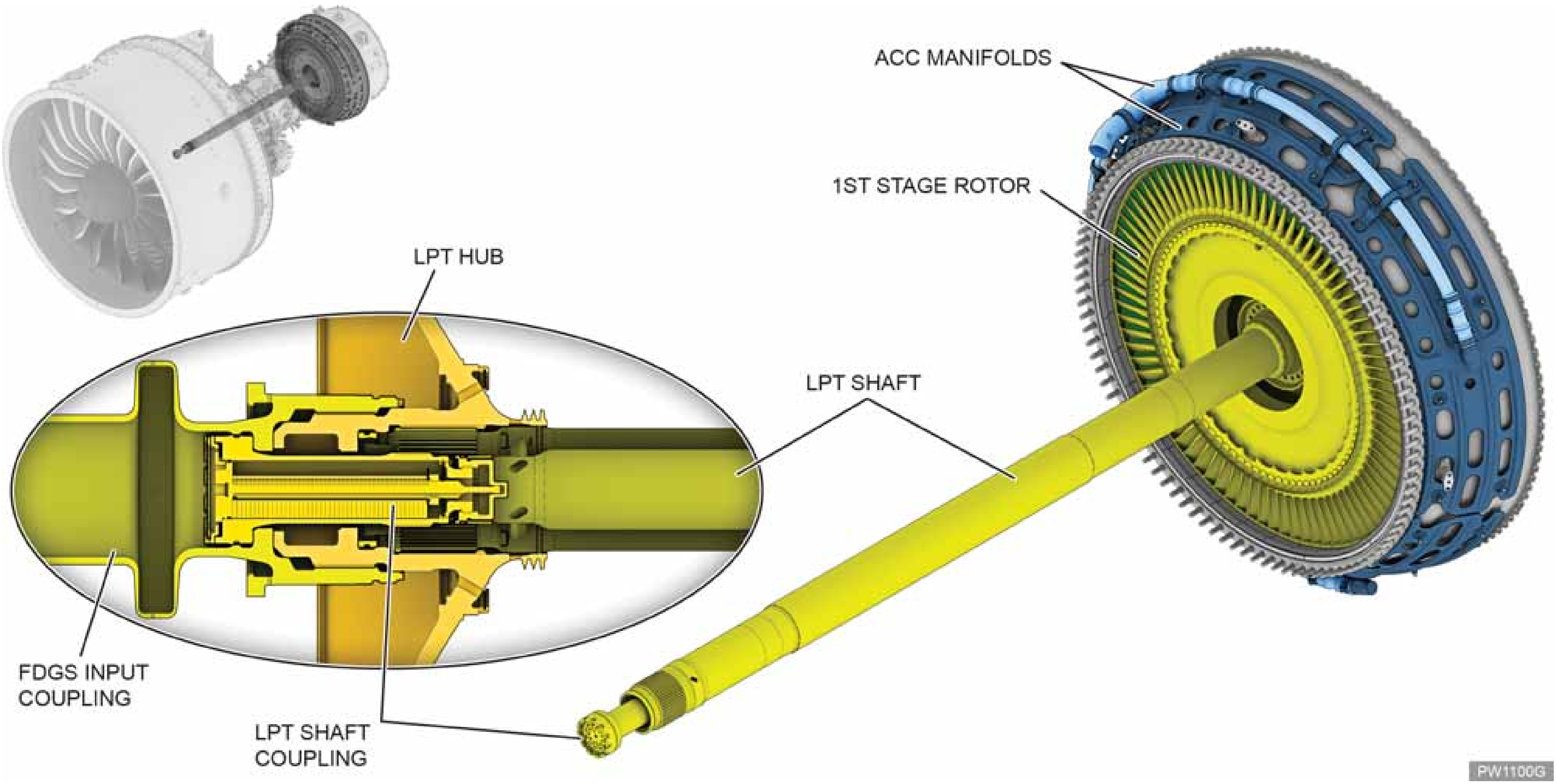
The 2nd Stage hub provides a splined attachment for the LPT shaft. The 1st and 3rd stage disks are bolted to the 2nd Stage hub and are cantilevered forward and aft. Disks feature integral rotating knife-edge air seals to limit gaspath leakage around the inner diameter of the stator vanes. All three turbine blade stages and 2nd Stage vanes are coated to protect against oxidation and sulfidation.

Operation:

The LPT drives the LPC and FDGS by extracting energy from the hot combustion gases, using the turbine blade and rotor assemblies. The spinning rotors are connected to the LPC by a turbine shaft that runs through the center of the engine.

The LPT case is cooled by the ACC manifolds.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



LOW PRESSURE TURBINE (LPT)

ENGINE MODULES (Cont.)

Turbine Exhaust Case (TEC)

Purpose:

The Turbine Exhaust Case is a main structural case that supports two main bearings and the rear engine mount, forming a transitional duct that collects and straightens exhaust gases.

Location:

The TEC attaches to the rear of the Low Pressure Turbine.

Description:

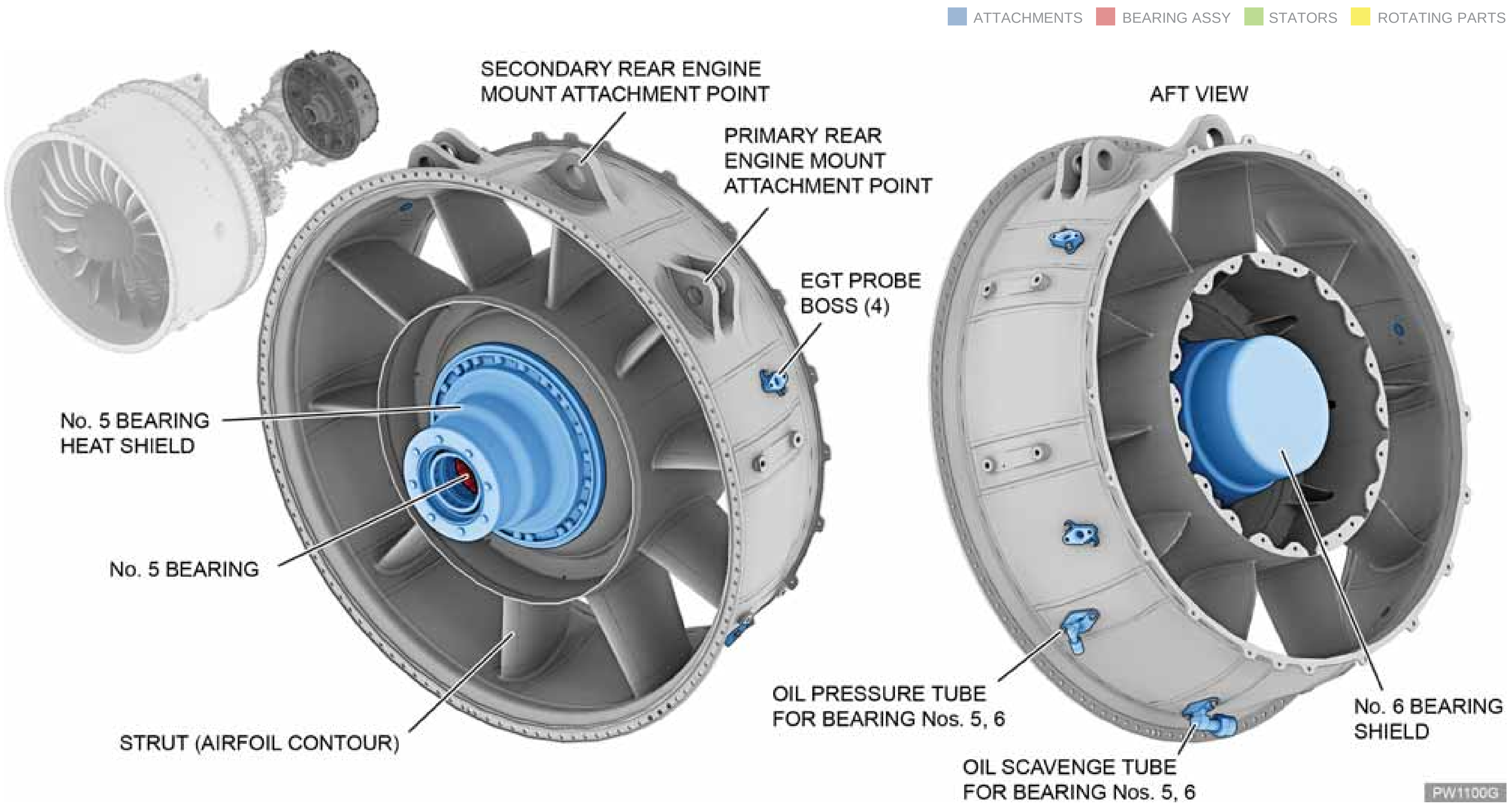
The TEC is a one-piece case assembly that supports roller bearing nos. 5 and 6. It has attachment points for the rear engine mount and the exhaust nozzle and centerbody.

Ten hollow struts provide radial support between the inner and outer cases. The bearings provide radial support for the LPT. The No. 6 Bearing is oil-damped. Oil leakage is controlled by a face-type carbon seal at the forward side of the No. 5 Bearing and by an oil plug at the rear of the LPT shaft. A heat shield reduces the high temperatures that can cause coking in the bearing compartment.

Oil and scavenge tubes for the bearings go through the bottom struts of the TEC.

Four Exhaust Gas Temperature (EGT) probes are mounted to bosses on the TEC outer case. The TEC also has mount points for Ground Support Equipment (GSE).

The outer case of the TEC has primary and secondary rear mount attachment points for the engine mount links that transmit the engine thrust loads to the airframe. The attachment points are integral to the TEC outer case.



TURBINE EXHAUST CASE (TEC)

ENGINE MODULES (Cont.)

Main Gearbox (MGB)

Purpose:

PMT

The Main Gearbox extracts mechanical power from the engine to drive system accessories that are mounted to pads on its forward and aft sides.

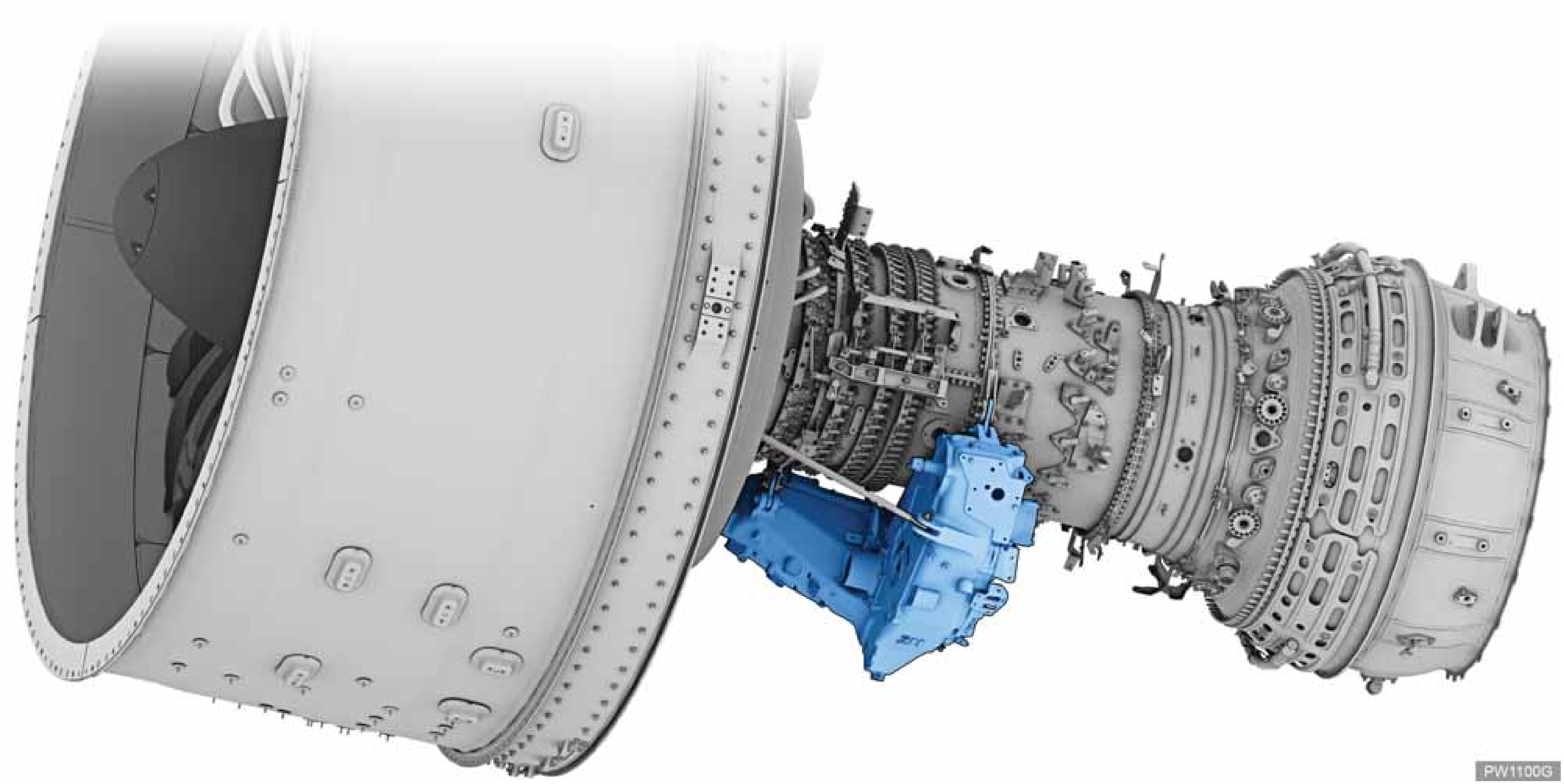
Location:

The MGB is mounted to brackets at 4:00 and 9:00 on the diffuser case.

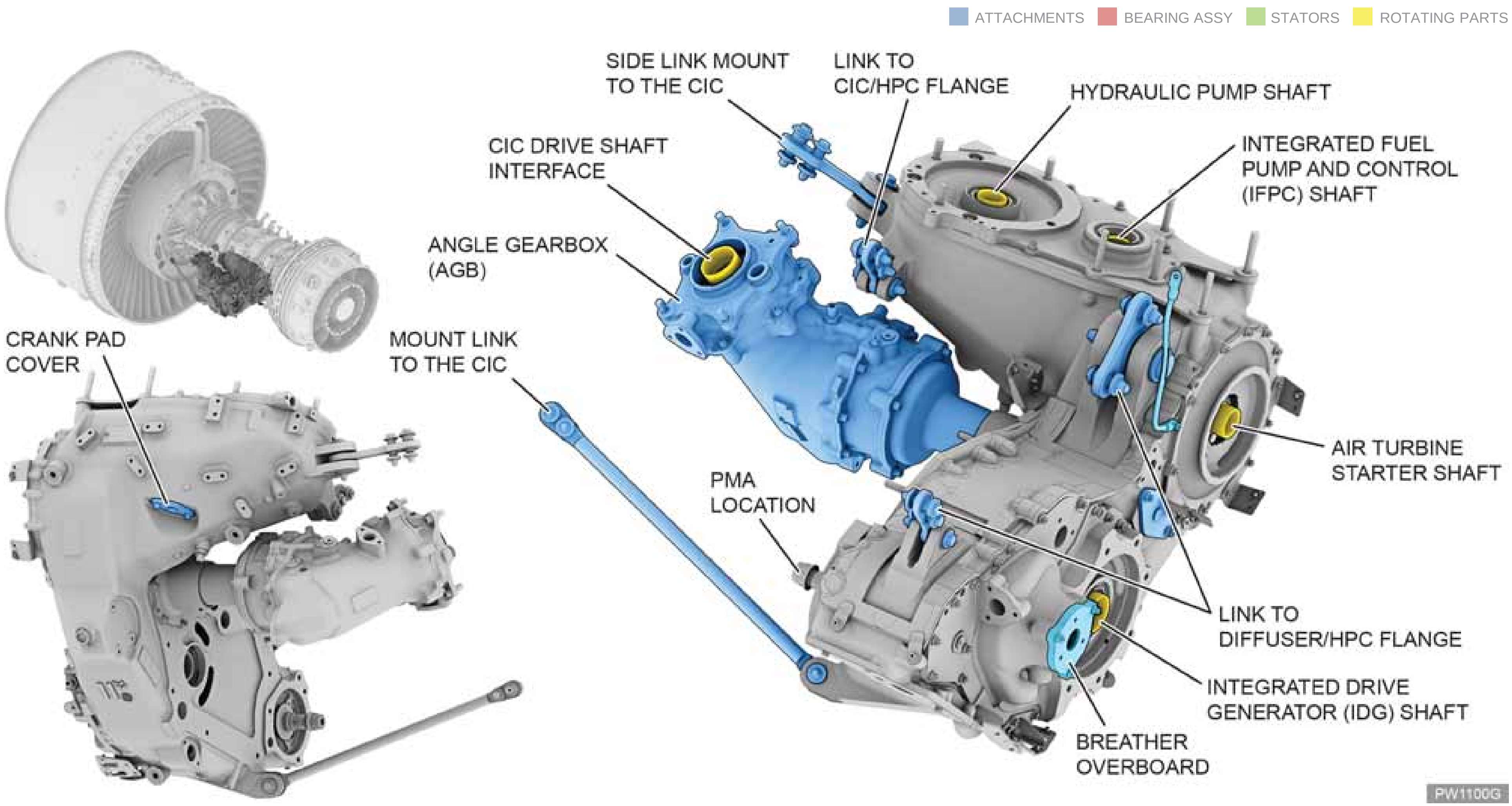
Description:

The MGB is a cast aluminum housing that contains gear sets and shafts to transmit mechanical power. Power from the MGB drives components in four system types: electrical, fuel, oil, and hydraulic.

The Main Gearbox Assembly is attached to the engine core at five locations using a series of brackets and links. The mounting bracket configuration is designed to ensure that failure of the mounting hardware is improbable. The configuration protects the links and mounting brackets from damage if the Main Gearbox should experience high loads due to a fan blade fracture.



ENGINE MODULES – MAIN GEARBOX LOCATION



MAIN GEARBOX (MGB) (AFT SIDE VIEW)

ENGINE MODULES

Main Gearbox (MGB) (Cont.)

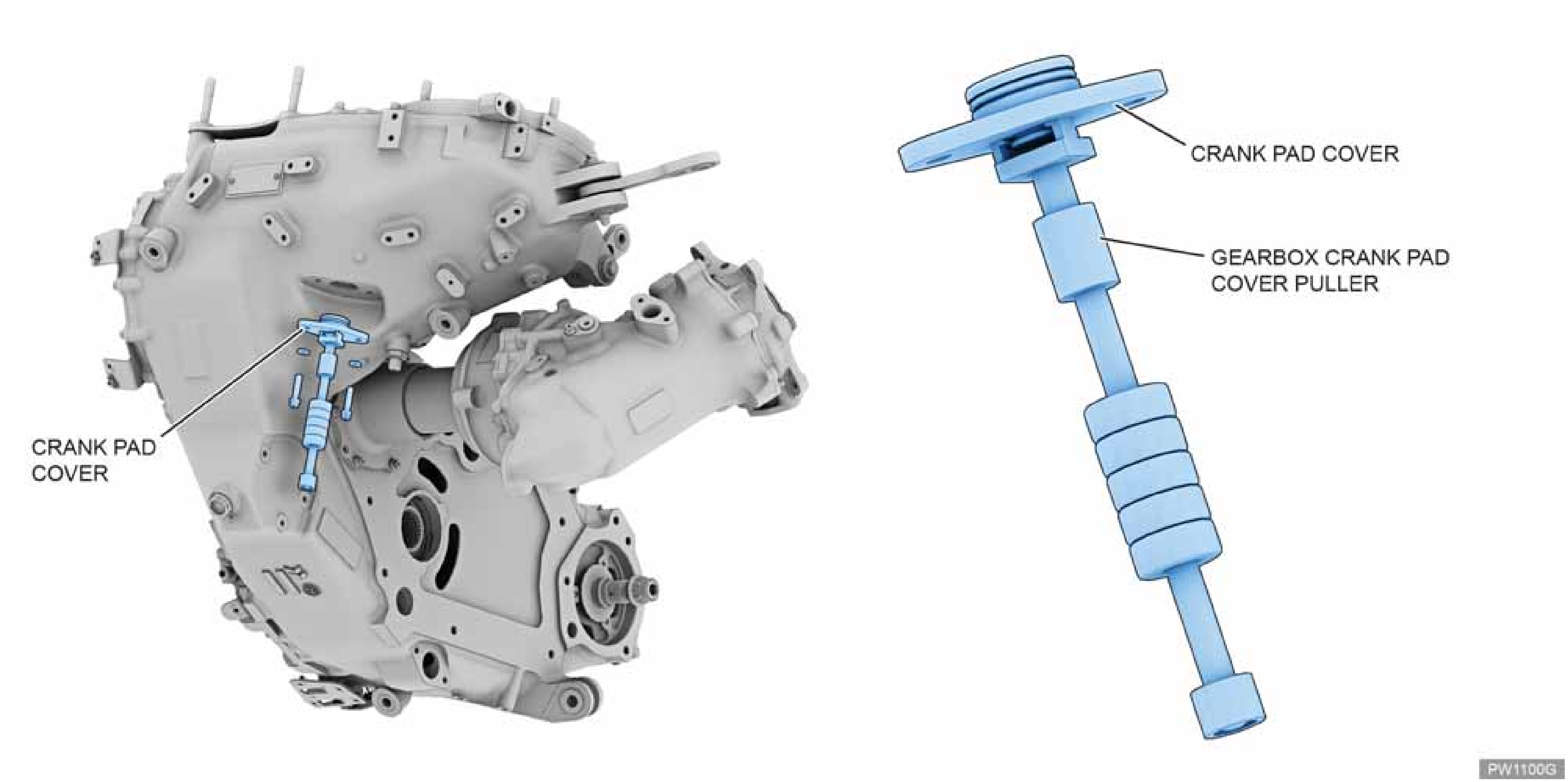
Operation:

Internal casting passages called *coring* supply oil to bearings and components. Carbon seals prevent oil leakage through the MGB front and rear walls.

A deoiler at the left rear of the MGB (aft looking forward) removes oil vapor from internal breather air before the air is released from the engine.

A crank pad is located at the left rear of the MGB housing to turn the HPC/HPT rotors when necessary for inspection.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



MAIN GEARBOX (MGB) – N2 CRANK PAD DRIVE

ENGINE MODULES

Main Gearbox (MGB)

Description (Cont.):

Components shown in the chart are mounted to the Main Gearbox.

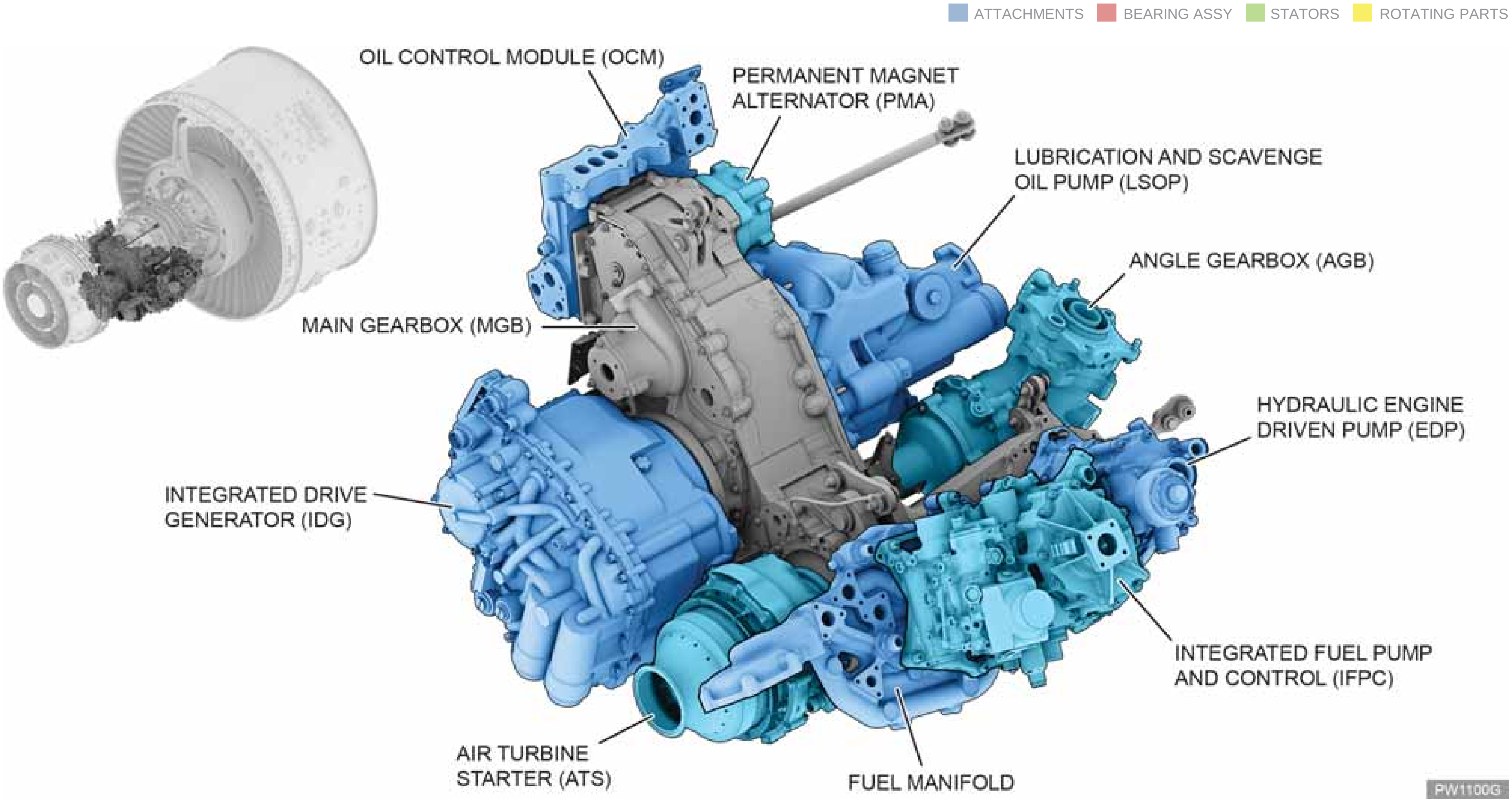
Operation:

1. A gearbox drive shaft in the Compressor Intermediate Case (CIC) engages the No. 3 Bearing bevel gear on the front of the HPC shaft.

2. The HPC/HPT rotational energy is transferred to the CIC tower shaft and then to the Angle Gearbox (AGB).

3. Torque coming through the AGB is supplied to the MGB through the MGB lay shaft. The MGB uses this power to drive components for a variety of systems.

<table>
<tr><th>Mounted Component</th><th>Location</th><th>System Type</th></tr>
<tr><td>Integrated Fuel Pump and Control</td><td rowspan="3">Right side</td><td rowspan="2">Fuel</td></tr>
<tr><td>Fuel Manifold</td></tr>
<tr><td>Hydraulic Engine Driven Pump</td><td>Hydraulic</td></tr>
<tr><td>Oil Control Module</td><td>Left side</td><td rowspan="2">Oil</td></tr>
<tr><td>Lubrication and Scavenge Oil Pump</td><td rowspan="2">Front</td></tr>
<tr><td>Permanent Magnet Alternator</td><td>Electrical</td></tr>
<tr><td>Integrated Drive Generator</td><td rowspan="2">Rear</td><td>Electrical</td></tr>
<tr><td>Air Turbine Starter</td><td>Air</td></tr>
</table>



MAIN GEARBOX (MGB) WITH ACCESSORIES (AFT VIEW)

ENGINE MODULES (Cont.)

Angle Gearbox (AGB)

Purpose:

The Angle Gearbox transfers power between the HPC/HPT and the MGB through a series of gear shafts.

Location:

The AGB is located at 6:00 on the engine core, between the Compressor Intermediate Case and the Main Gearbox Assembly.

Description:

The AGB Assembly contains the Angle Gearbox housing, gear shafts, lay shaft and lay shaft covers. The AGB acts as a connection between the HPC and the MGB, providing torque power to drive components for a variety of systems.

The MGB drive shaft passes through a front and rear cover.

The AGB housing supports ball and roller bearings that hold the gear shafts in position. The CIC attachment flange and O-rings are part of the housing as well.

Safety Conditions

CAUTION

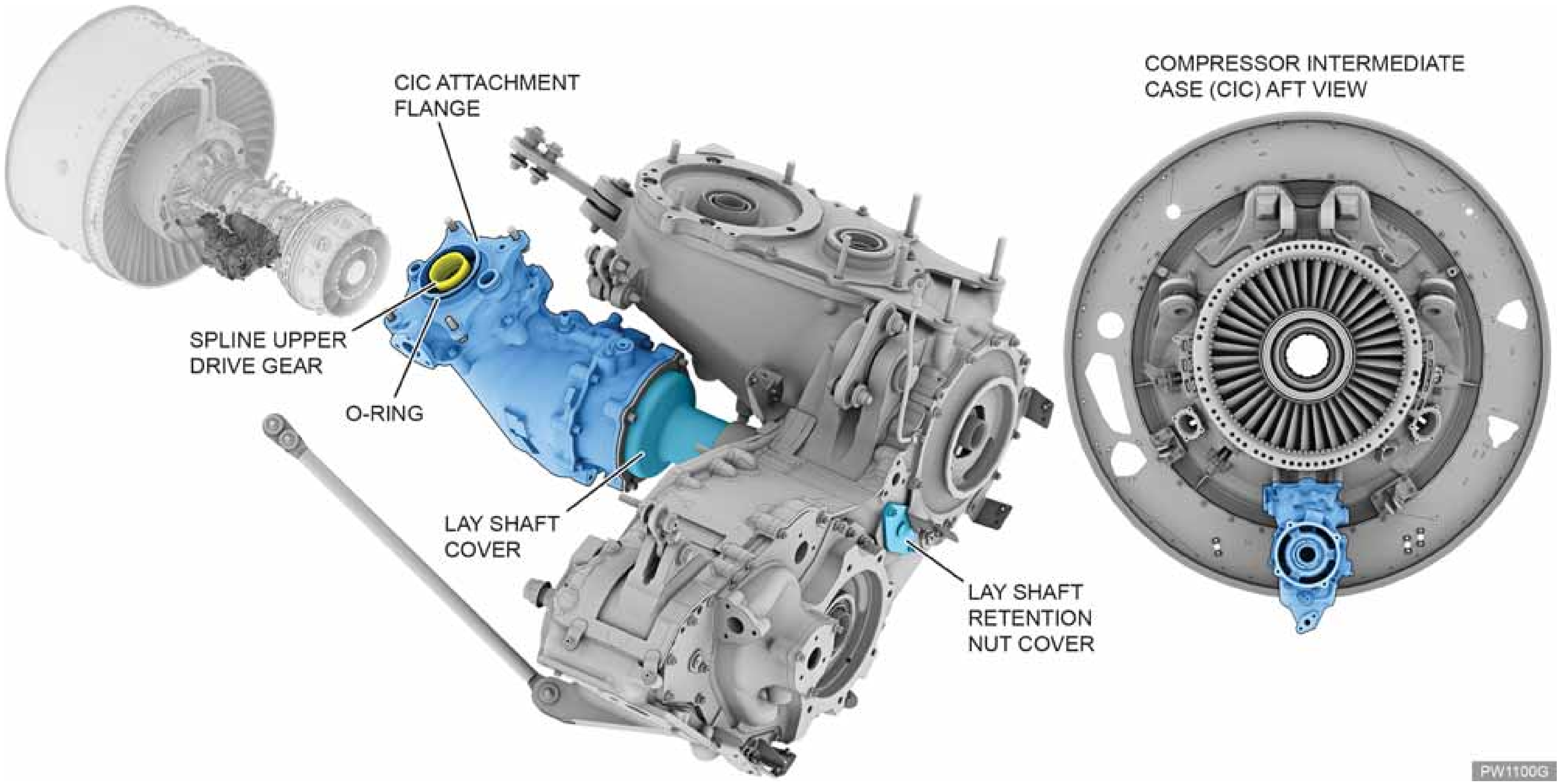
MAKE SURE THE LAYSHAFT IS CLEAR OF THE ANGLE GEARBOX BEFORE REMOVAL.

Pick-up teeth on the radial bevel gear allow the N2 speed sensor to measure High Pressure Compressor rotor speed.

Operation:

During operation, the power from the HPC is transmitted to the gearbox drive shaft and into the AGB upper drive gear. The AGB then transmits the torque to the MGB through bevel gears and the lay shaft.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



ANGLE GEARBOX (AGB) WITH MOUNT LOCATION

ENGINE MODULES (Cont.)

Main Gearbox Oil Seals: Hydraulic Pump, IDG, IFPC, and Deoiler Drive

Purpose:

LRU

The drive seals prevent oil loss from the MGB at the interface between the gearbox and the component drive.

Location:

The seals for the Hydraulic Pump, IDG, IFPC and deoiler are located on their respective drive pads on the MGB.

Description:

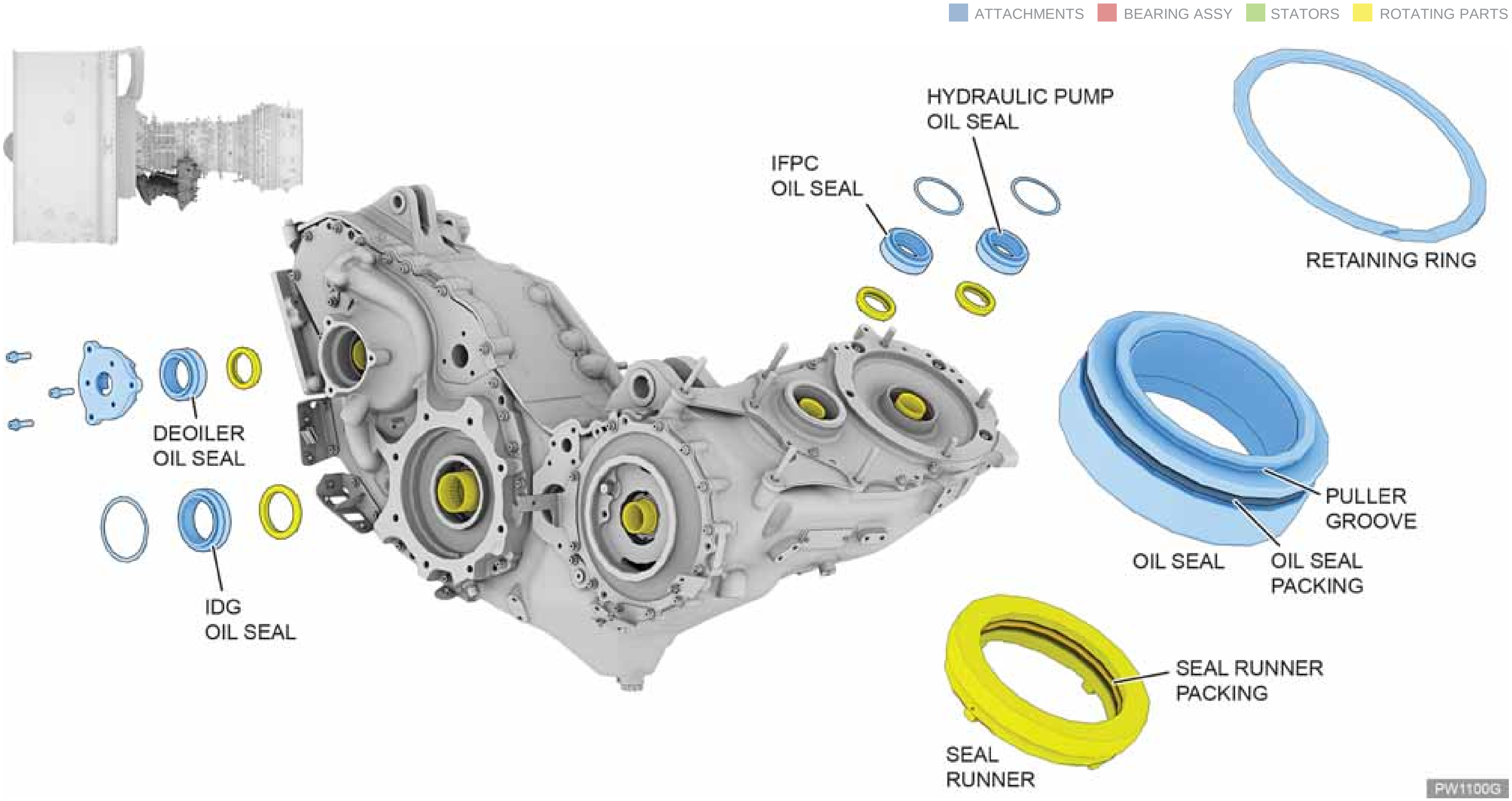
Each spring-loaded, carbon-faced seal has an integrated oil jet to cool its seal runner.

The seal housing assembly is held in place by a retaining ring and has a puller groove used to remove the assembly. The seal runner and carbon seal are replaced together. Packings are used between the seal housing and MGB housing, and between the runner and drive shaft.

Safety Conditions

CAUTION

HANDLE THE OIL SEAL WITH CARE. DO NOT SCRATCH OR DAMAGE THE CARBON SEALING SURFACE DURING HANDLING OR INSTALLATION. IF YOU SCRATCH OR DAMAGE THE CARBON SEALING SURFACE, YOU CAN NOT REPAIR IT. THE SEAL ASSEMBLY MUST BE REPLACED.



MAIN GEARBOX (MGB) OIL SEALS

ENGINE MODULES

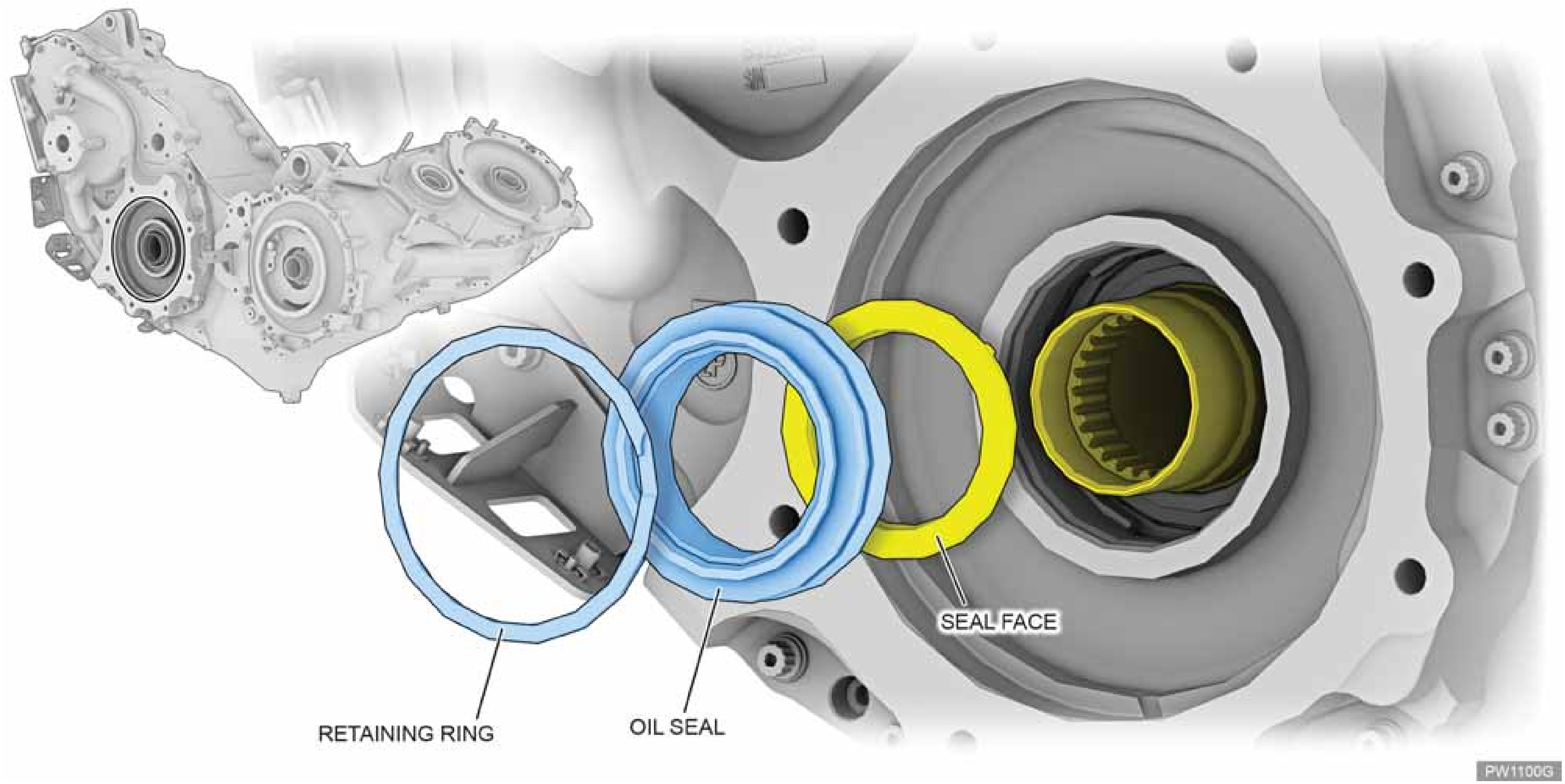
Main Gearbox Oil Seals: Hydraulic Pump, IDG, IFPC, and Deoiler Drive (Cont.)

Operation:

1. The drive seals create a seal between the static, spring- loaded carbon face and the rotating seal runner. A wave spring behind the carbon face forces it to seat against the runner. The runner sealing surface is highly polished and parallel, creating a tight seal.

2. The runner is installed on the MGB shaft that drives the component. The shaft turns the runner that seals against the carbon, creating an effective seal that eliminates oil leakage from the MGB. Oil is sprayed on the runner to reduce its operating temperature.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS

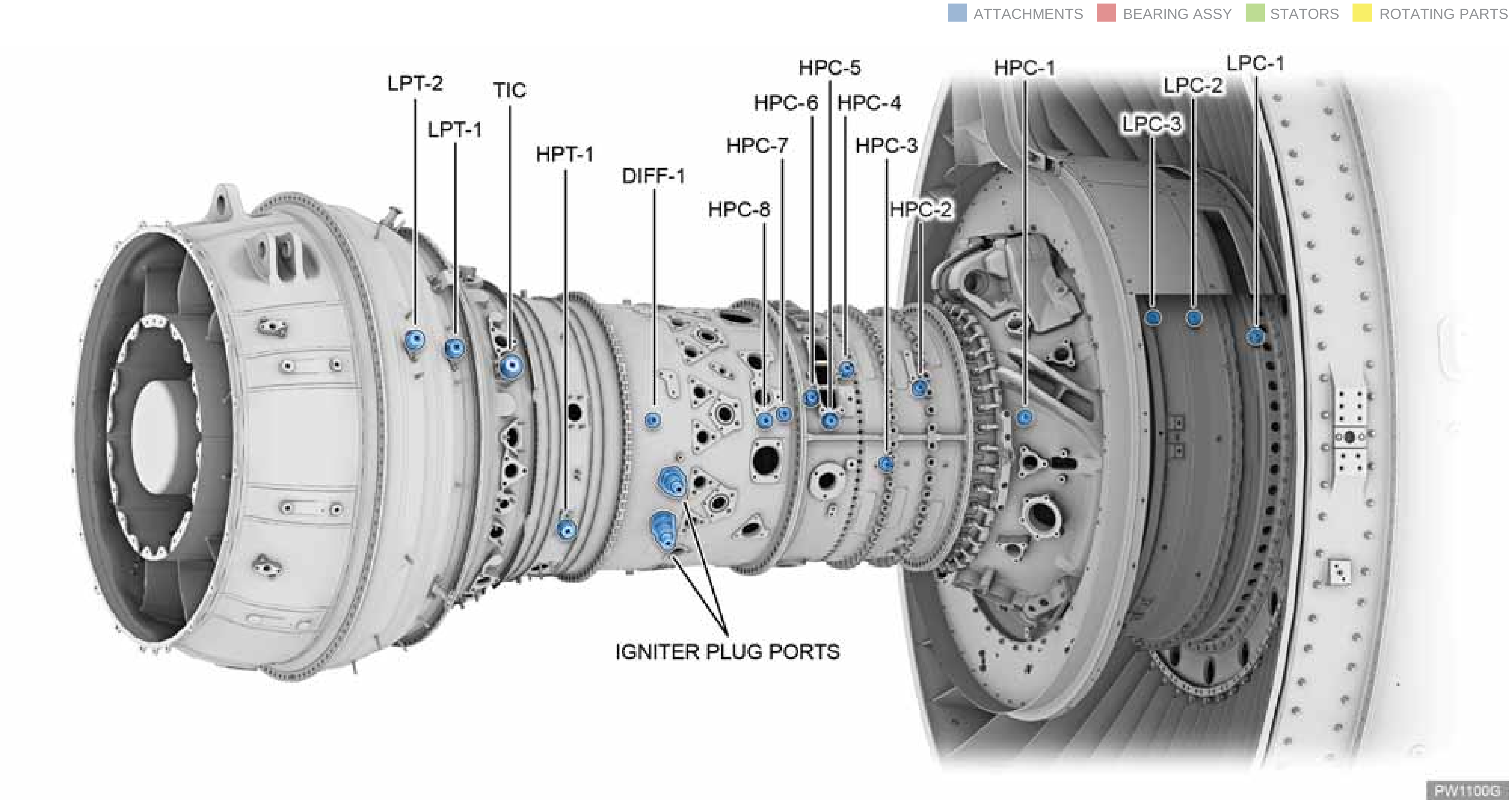


MAIN GEARBOX (MGB) OIL SEAL INSTALLATION

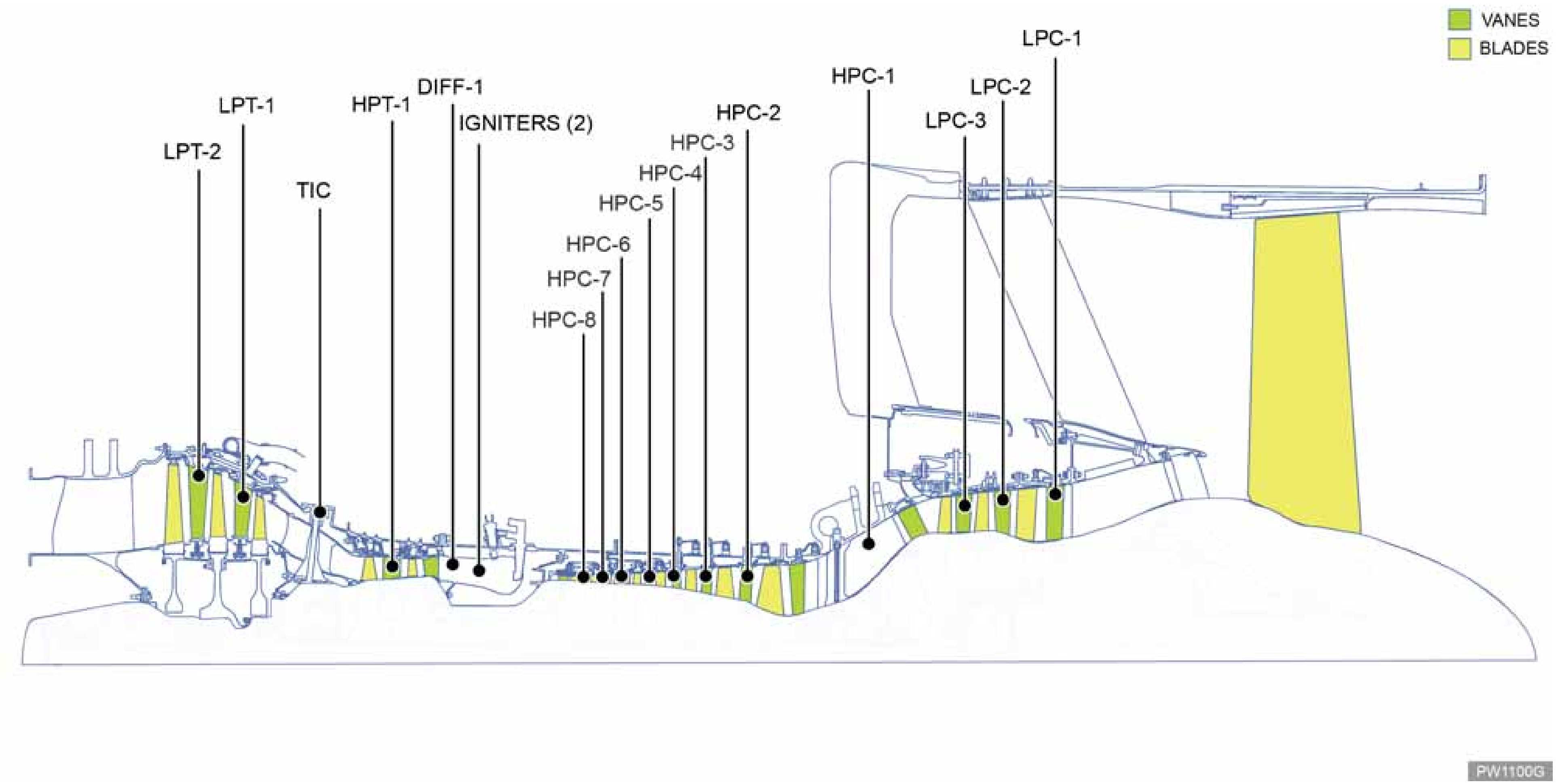
ENGINE MODULES (Cont.)

Borescope Access

The borescope procedure permits visual inspection of internal gaspath parts without the need for engine disassembly. A borescope probe is inserted through any of several access ports (APs) to inspect parts for damage, cracks, wear, and missing material. Igniter plug locations can also be used for access once the plugs are removed.



BORESCOPE ACCESS PORTS (1 OF 2)



BORESCOPE ACCESS PORTS (2 OF 2)

AP	Location	Inspection Area
LPC-1		Inlet vanes; 1st Stage vanes; 1st Stage blades
LPC-2	2:00	1st Stage vanes, 2nd Stage blades
LPC-3		2nd Stage vanes, 3rd Stage blades
HPC-1		Inlet guide vanes, 1st Stage blade
HPC-2	3:00	1st Stage stator, 2nd Stage blade
HPC-3	3:30	2nd Stage stator, 3rd Stage blade
HPC-4	1:30	3rd Stage stator, 4th Stage blade
HPC-5	3:00	4th Stage stator, 5th Stage blade

AP	Location	Inspection Area
HPC-6	1:30	5th Stage stator, 6th Stage blade
HPC-7 (DIFF case)	3:00	6th Stage stator, 7th Stage blade
HPC-8 (DIFF case)		7th Stage stator, 8th Stage blade
Igniter plug ports	3:30/4:00	Combustion chamber inner and outer liner; fuel nozzles; 1st Stage nozzle guide vanes
DIFF-1	3:00	
HPT-1	4:00	1st Stage rotor; 2nd Stage stator; 2nd Stage blade
TIC		HPT 2nd Stage blade rear, LPT 1st Stage blade front
LPT-1	2:00	1st Stage rotor; 2nd Stage stator; 2nd Stage blade
LPT-2		2nd Stage rotor; 3rd Stage stator; 3rd Stage blade

BORESCOPE ACCESS PORT INSPECTION AREAS

CHAPTER 3

FUEL AND ENGINE CONTROL

ATA 73

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT	A Post Maintenance Test is required.
WARNING	Avoid injury by follow guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of these systems:
    - Engine Control
    - Fuel Distribution
    - Fuel Indicating
2. Locate system components.
3. Identify Line Replaceable Units (LRUs).

OVERVIEW

Fuel and Engine Control operations are divided between the Engine Control System and the Fuel System. The Fuel System is further subdivided into Fuel Distribution and Fuel Indicating.

Engine Control

This system commands engine systems and fuel flow. It maintains stable engine thrust and performance during all phases of operation. It also interfaces with aircraft displays and computers.

Fuel Distribution

This subsystem supplies metered fuel for combustion and servo fuel pressure for component actuators.

Fuel Indicating

This subsystem monitors the condition of the Fuel System. It displays flight deck warnings that alert the crew to Fuel System status and to potential problems.

Safety Conditions

WARNING

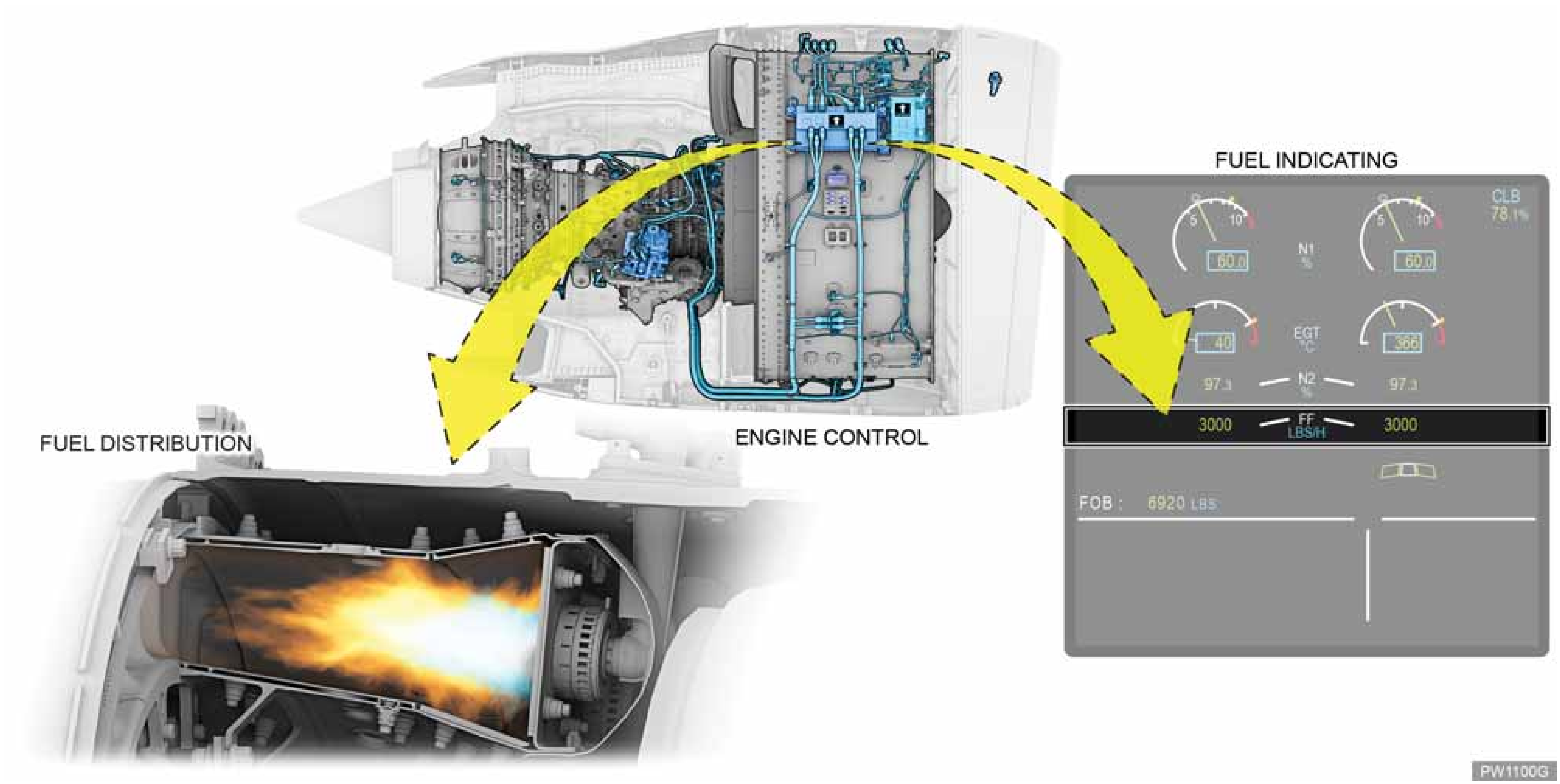
REFER TO THE SAFETY DATA SHEET (SDS) FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.



FUEL AND ENGINE CONTROL OPERATIONS

ENGINE CONTROL SYSTEM

The Engine Control System regulates and monitors engine operations using the Full Authority Digital Electronic Control (FADEC). FADEC is a computer-based system that acts as the primary interface between the engine and aircraft systems.

Found in both aircraft and engine systems, FADEC components work together to improve efficiency, enhance control functions, protect the engine, and provide operational reliability. Numerous FADEC aircraft and engine components are overseen by the Electronic Engine Control (EEC), which is itself a component of the FADEC system. The EEC sends, receives, and interprets information between aircraft and engine systems, while controlling and monitoring engine functions in systems including Fuel, Air, Starting, Oil, Thrust Reverser and Thermal Management.

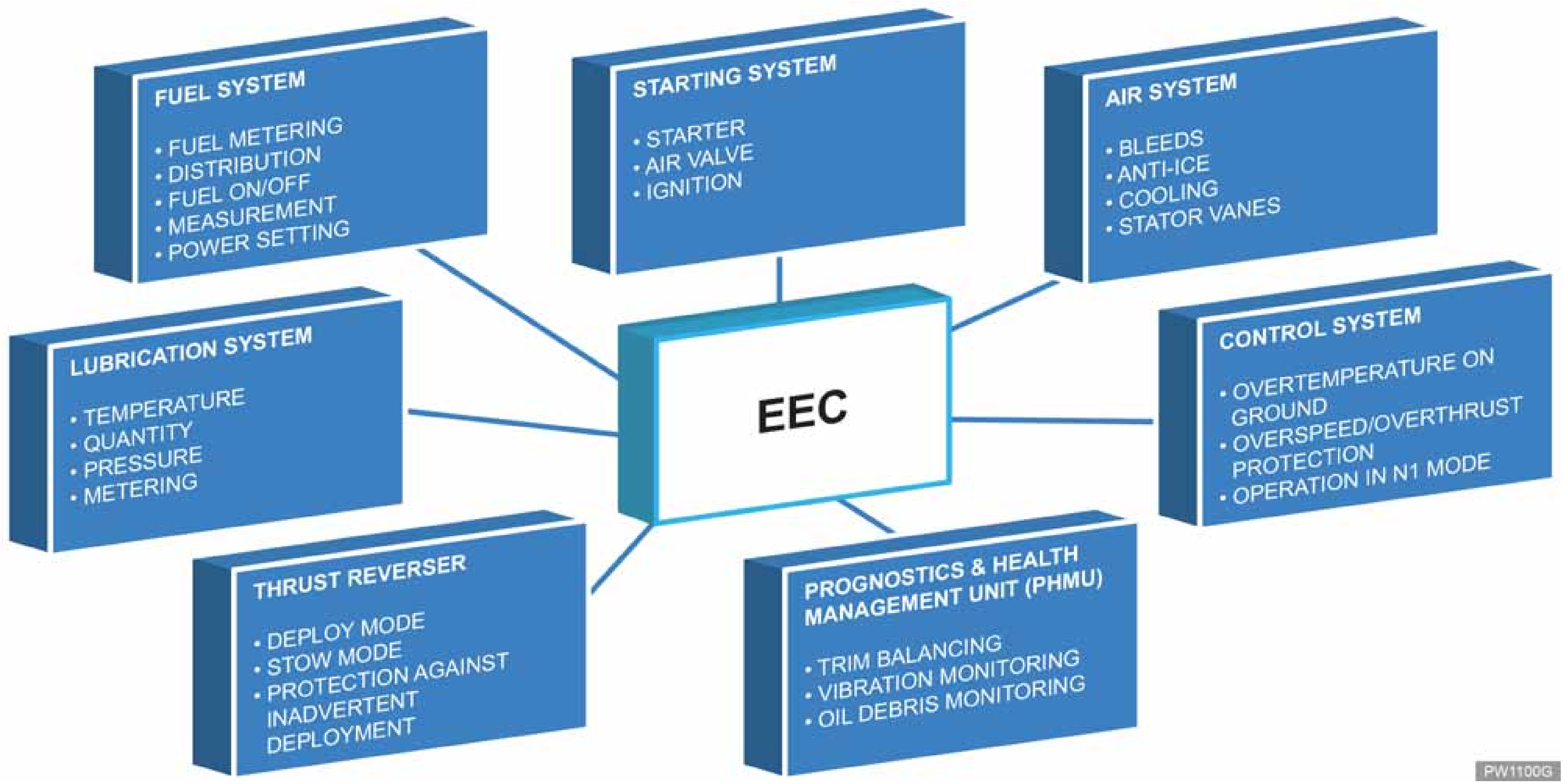
In conjunction with the engine's Prognostics and Health Management Unit (PHMU), the EEC analyzes the condition of the engine based on operating parameters such as rotor rpm, fuel flow and exhaust gas temperatures. Engine condition information is recorded and sent in real time to ground maintenance stations, and to the aircraft in the form of maintenance, caution, warning and status messages.

KEY FACT

FADEC controls a variety of major functions, shown below.

- Engine thrust parameter (N1)
- Performance features, such as stability and cooling
- Thrust reverser
- Overspeed/Thrust Control Malfunction (TCM) System Protection
- Auto start

FADEC also limits EGT and performs engine diagnostic and health management.

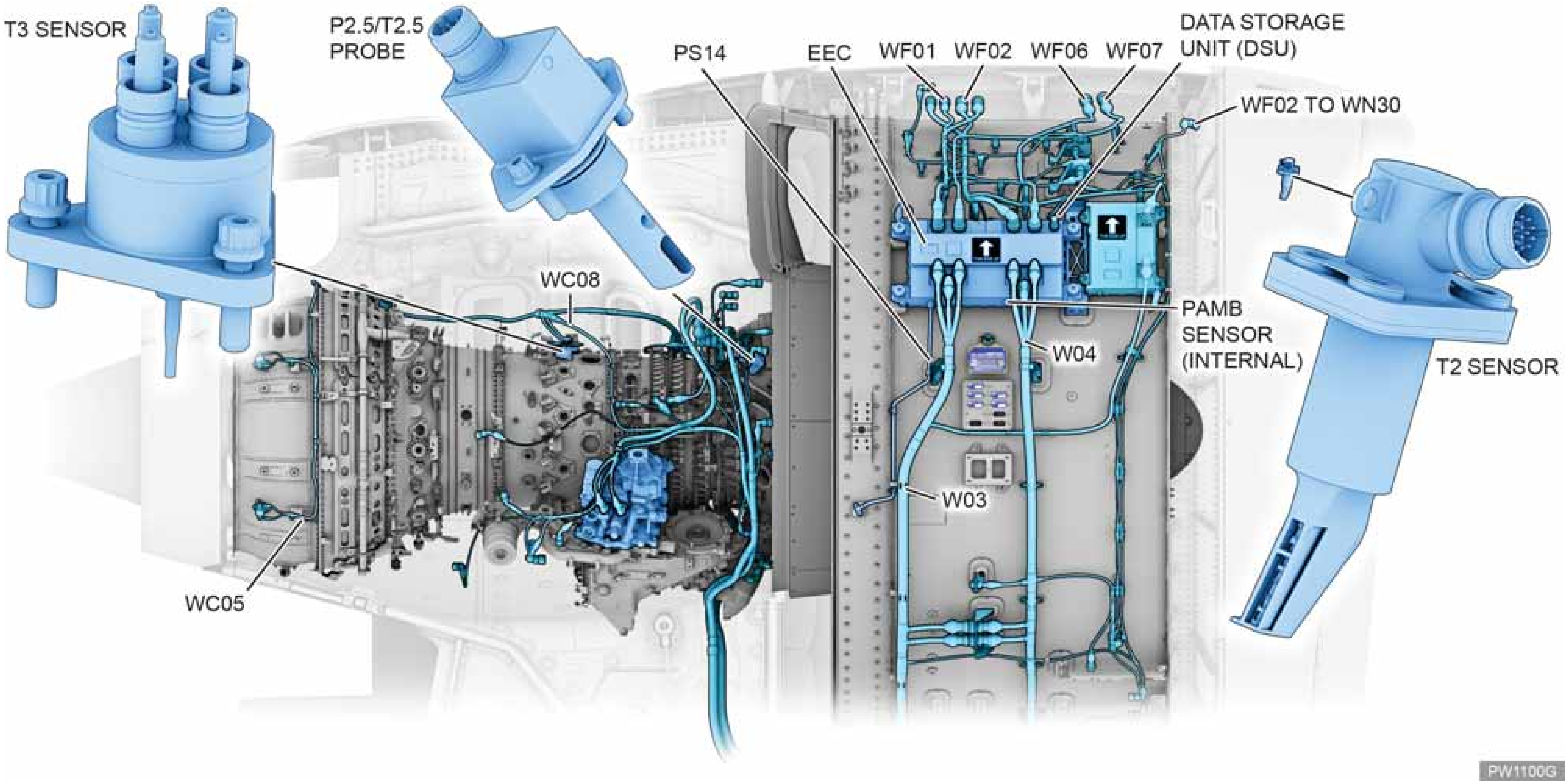


ENGINE CONTROL SYSTEM – ELECTRONIC ENGINE CONTROL (EEC) INTERFACE

ENGINE CONTROL SYSTEM (Cont.)

Components found on the right side of the engine are listed below.

• Electronic Engine Control	EEC
• Data Storage Unit	DSU
• Pressure and temperature probe at Station 2.5	P2.5/T2.5
• Wiring harnesses	W (03, 04)
o Fan	WF (01, 02, 06, 07)
o Core	WC (05, 08)
o Nacelle	WN (30)
• Ambient pressure sensor	Pamb
• Temperature sensor at Station 2	T2
• Temperature sensor at Station 3	T3
• Pressure sensor at Station 14	PS14

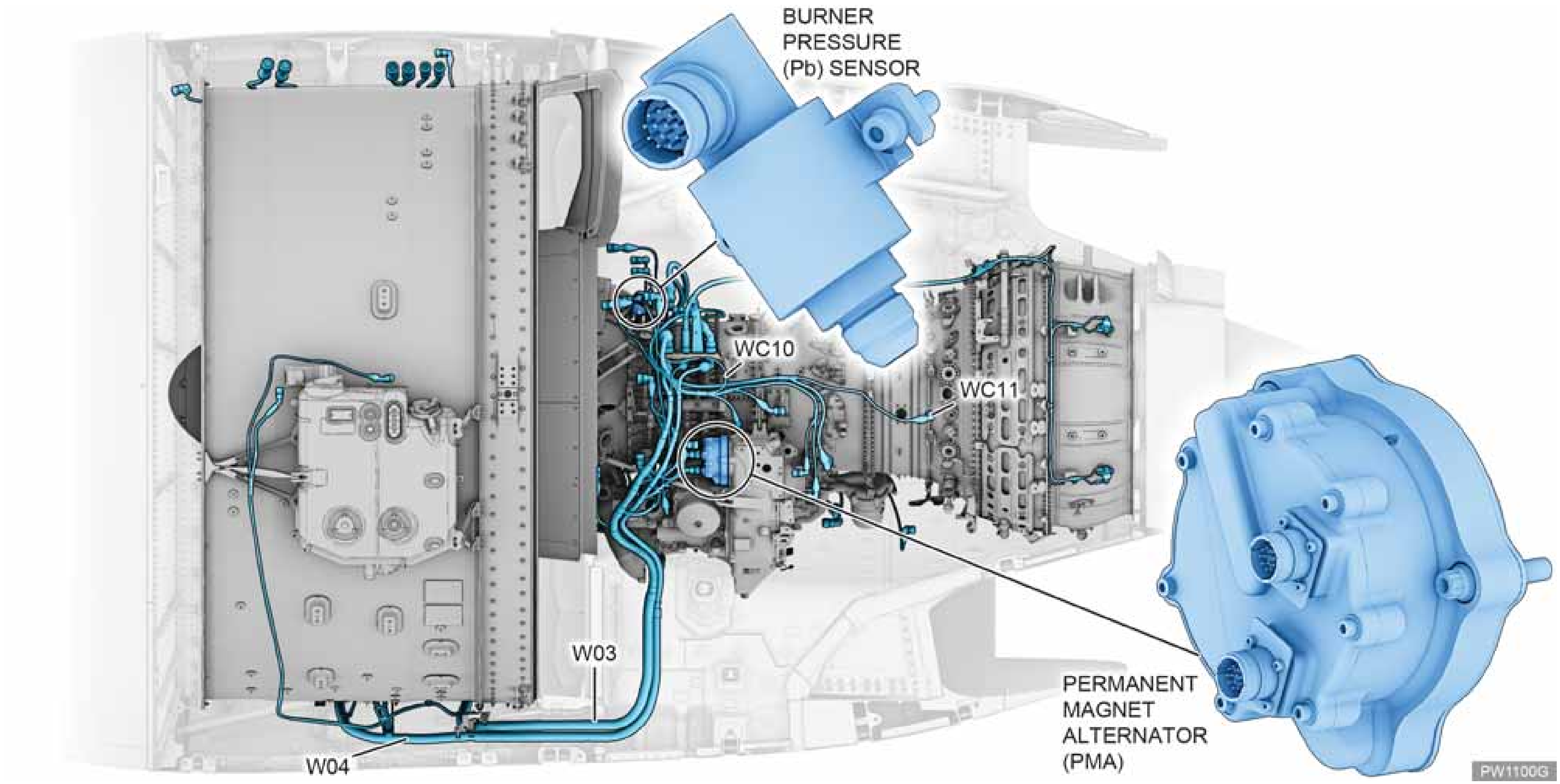


ENGINE CONTROL SYSTEM COMPONENTS – RIGHT SIDE

ENGINE CONTROL SYSTEM (Cont.)

Components found on the left side of the engine are listed below.

• Burner pressure sensor	Pb
• Permanent Magnet Alternator	PMA
• Wiring harnesses	
o Fan	W (03, 04)
o Core	WC (10, 11)



ENGINE CONTROL SYSTEM COMPONENTS – LEFT SIDE

ENGINE CONTROL SYSTEM (Cont.)

Electronic Engine Control (EEC)

Purpose:

LRU PMT

The Electronic Engine Control is designed to interface with aircraft displays and computers, control engine fuel flow, and maintain stable engine operation during all flight phases. The EEC controls subsystem components to maintain oil and fuel temperature within specified limits and improve engine performance.

The EEC also monitors the health of all subsystems and reports this information to the aircraft. Aircraft computers generate Crew Alerting System (CAS) messages and Clear Language Messages (CLM) for engine reliability, efficiency, and ease of maintenance.

The EEC sends command signals from the FADEC System and receives and interprets FADEC signals in turn. It energizes and de-energizes solenoids, and performs parameter calculations to control and monitor engine systems including Fuel, Air, Oil, Starting/Ignition, and thrust and limits controls. The EEC also controls the Nacelle Anti-Ice System and monitors the Thrust Reverser System. It sends signals to the flight deck to communicate the status of the FADEC System and its interfacing components.

Safety Conditions

CAUTION

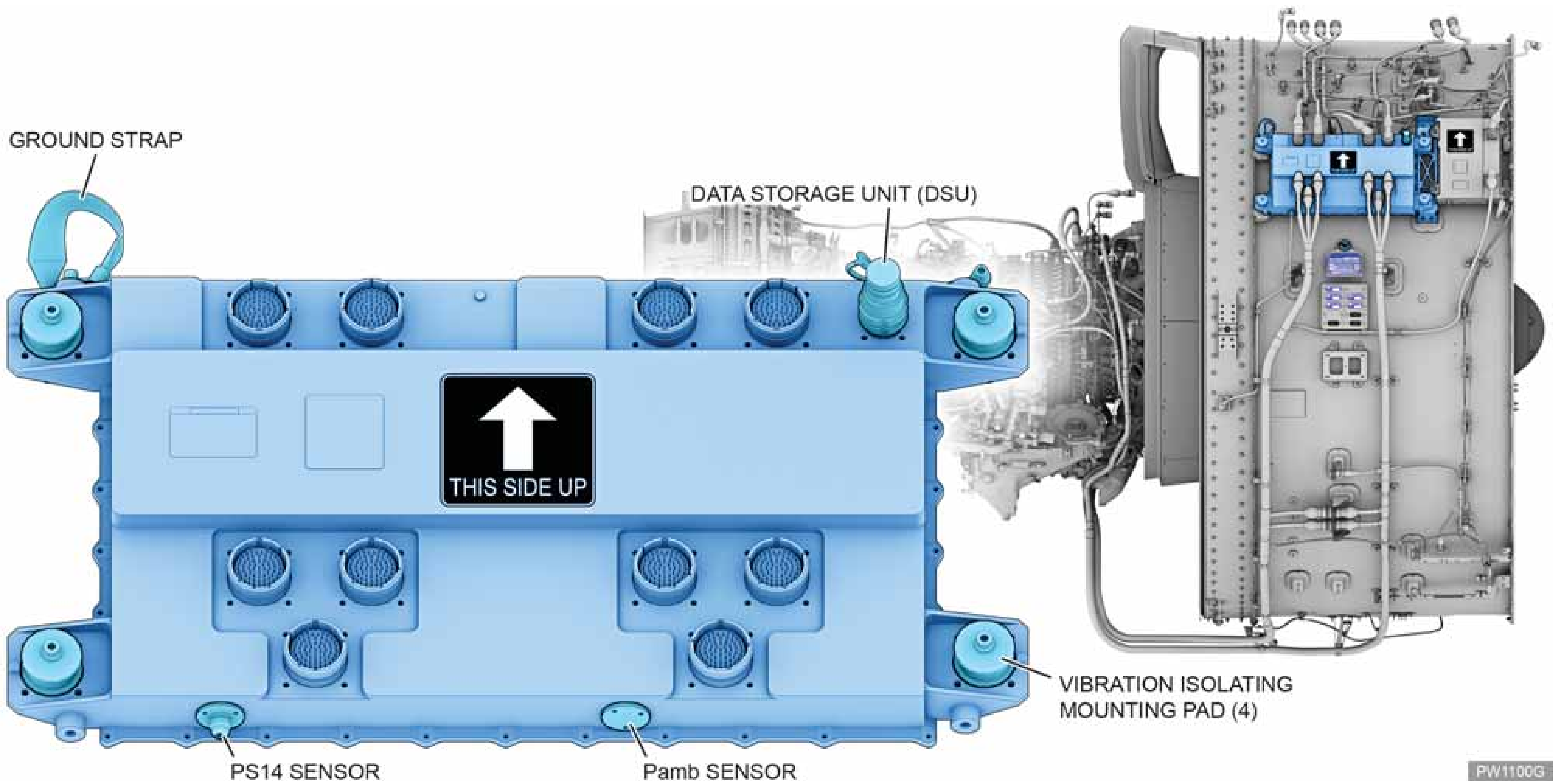
MAKE SURE THAT THERE IS NO POWER TO THE EEC DURING THE REPLACEMENT OF THE EEC AND WHEN YOU REMOVE THE DATA STORAGE UNIT (DSU). IF THERE IS POWER TO THE EEC DURING THIS TASK, DAMAGE TO THE EEC OR DSU CAN OCCUR.

MAKE SURE THE DSU REMAINS WITH THE ENGINE WHEN THE EEC IS REMOVED. IF YOU DO NOT OBEY THIS CAUTION AND AN INCORRECT DSU IS INSTALLED, ENGINE OPERATION CAN BE AFFECTED.

IF ONLY THE EEC WAS REPLACED, MAKE SURE THAT THE DSU INSTALLED ON THE ENGINE IS REINSTALLED IN THE REPLACEMENT EEC. IF YOU DO NOT OBEY THIS, ENGINE OPERATION MAY BE AFFECTED.

PUT CAPS OR COVERS ON ALL OPEN PORTS OF ENGINE COMPONENTS TO PREVENT CONTAMINATION OF THE INTERNAL SURFACES.

MAKE SURE YOU HOLD THE EEC WHILE YOU REMOVE THE BOLTS. IF YOU DO NOT HOLD THE EEC, IT CAN FALL AND CAUSE DAMAGE TO THE EEC AND OTHER ENGINE PARTS.



ENGINE CONTROL SYSTEM – ELECTRONIC ENGINE CONTROL (EEC)

ENGINE CONTROL SYSTEM

Electronic Engine Control (EEC) (Cont.)

Location:

The EEC is attached with four vibration isolating mounting pads to the Fan Case Assembly at 2:30.

Description:

The EEC receives power from the Permanent Magnet Alternator (PMA) or from the aircraft in case of PMA failure. For maintenance purposes and instances when N2 is less than 8 percent (such as at starting), ground power for the EEC comes from two 28V DC aircraft power sources. Each power source supplies one of the EEC's two redundant channels. Each of the two channels has its own processor, program memory, power supply, input sensors and output signal.

- The processors, program memory, and power supply are contained with 11 external electrical receptacles in a cast aluminum housing that is cooled by natural convection.
- The processors respond to and process information based on the logic and data stored in program memory.
- The pressure sensors measure fan exit air pressure (PS14) and ambient air pressure (Pamb), respectively.

EEC channel A is powered by a DC Essential (DC ESS) Bus. When the EEC powers up, it conducts an automatic built-in test to verify its integrity. If the EEC fails the built-in test, it will send a signal to the Electronic Centralized Aircraft Monitor (ECAM) on the flight deck.

Each EEC channel has five electrical connectors to send command signals and receive signals. One electrical connector provides attachment for the Data Storage Unit (DSU).

The EEC is re-programmable on-wing using the Common Engine Software Loader (CESL).

Engine	Channel	Bus Supply
1	A	DC ESS
	B	DC BAT
2	A	DC ESS
	B	DC 2

Channel	Connector	Wiring
A	J1	Aircraft/engine
	J3, J5, J13	Engine
	J7	Nacelle
	J99	DSU connector
B	J2	Aircraft/engine
	J4, J6, J14	Engine
	J8	Nacelle

ENGINE CONTROL SYSTEM – POWER BUS SUPPLY AND WIRING

ENGINE CONTROL SYSTEM

Electronic Engine Control (EEC) (Cont.)

Description (Cont.):

The EEC interprets temperatures, pressures such as ambient pressure (Pamb), and rotor speeds for correct manipulation of the engine across all operating conditions. These speed indicators and their primary roles are shown in the chart.

Operation:

During normal operation the EEC is in active/standby mode, where all engine functions are controlled by the channel selected for the flight. Channels alternate from one flight to the next. The switchover is done at every engine shutdown.

The EEC continuously evaluates the health of each channel during engine operation. The channel with the best health score during operation will be in control, or “Active.”

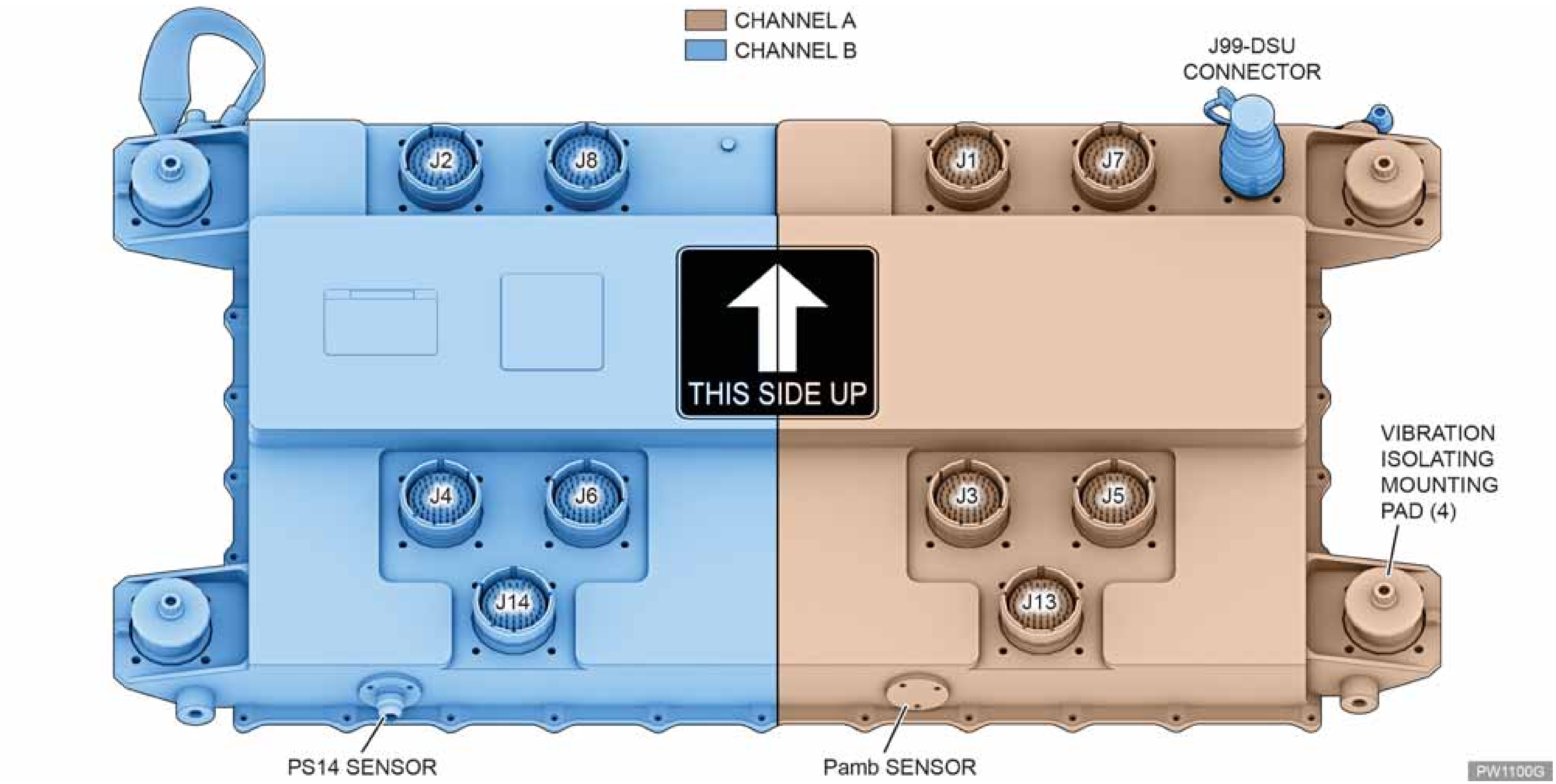
Engine Limits Protection

The EEC’s control laws provide limit protection for burner pressure, and for high and low (N1 and N2) rotor speeds.

Speed Indicator	Primary Role
N1 / Low rotor	Primary parameter for thrust control
N2 / High rotor	Fuel scheduling
Nf / Fan rotor	Vibration monitoring

The Overspeed (OVSP) logic provides a means of cutting the fuel flow to the engine. It is energized when an engine overspeed condition is detected, during self-test operation, and when an engine shutdown is commanded. Overspeed limit, or “trip point,” is 105 percent. During normal operation, the EEC will limit the engine to redline speeds of 100 percent for both rotors. The EEC uses a highly redundant electronic overspeed system to shut off fuel to the engine in case of either N1 or N2 exceeding the overspeed limit.

For operation between 100 percent and the overspeed trip point limits, the EEC will generate a change in color of the N1 and/or N2 speed value from green to red within the Electronic Centralized Aircraft Monitor (ECAM). The pilot is expected to take action to bring the engine operation within limits.



ENGINE CONTROL SYSTEM – EEC INTERFACE CHANNELS AND CONNECTORS

ENGINE CONTROL SYSTEM

Electronic Engine Control (EEC) (Cont.)

Reliability Features

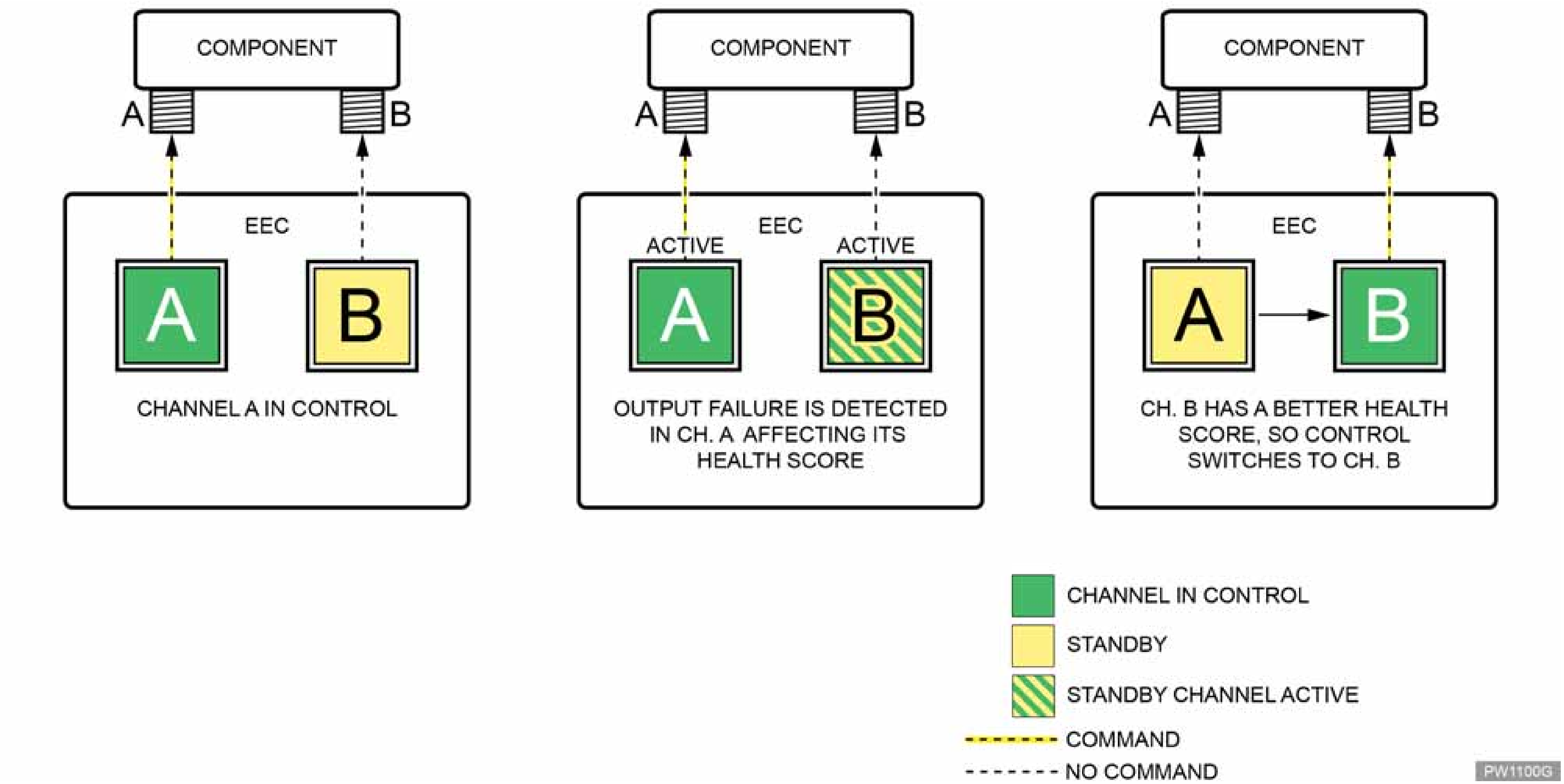
Improved EEC reliability is provided by dual sensors, control channels and feedback. The sensors receive inputs that provide electrical signals to the EEC. The EEC uses identical software in each of the two channels. The mode of operation and the selection of the channel in control is decided by the availability of input signal and output controls.

Each channel normally uses its own input signals. If faulty or suspect inputs are recognized on one channel, input signals from the other channel can also be used.

An output fault in the controlling channel will cause the EEC to switch control to the other channel in active stand-by mode, provided that channel is functional.

If faults are detected in both channels, a pre-determined hierarchy decides which channel is more capable.

If both channels are lost, or electrical power is lost, engine systems are designed to go to the failsafe positions.



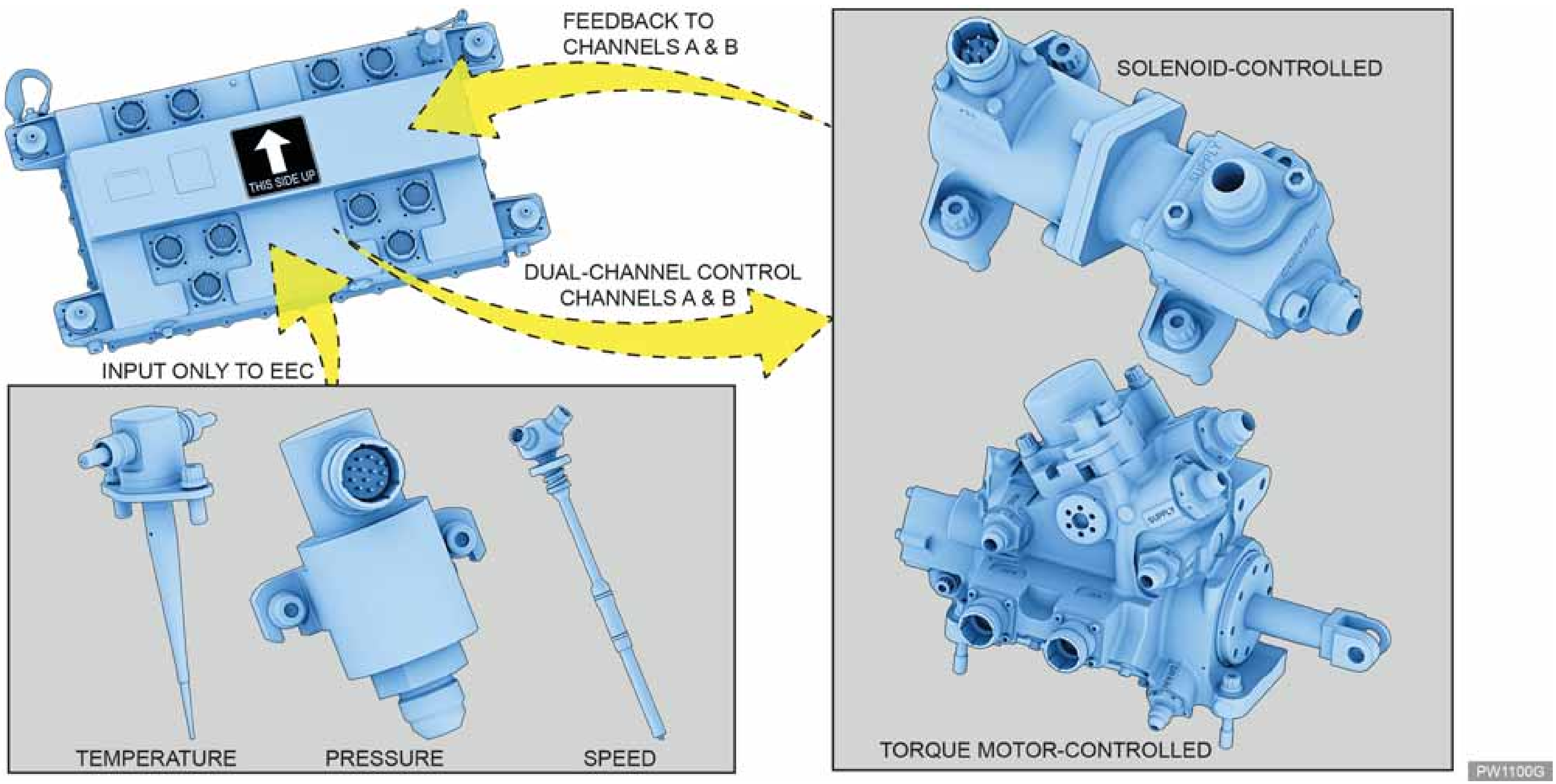
ENGINE CONTROL SYSTEM – EEC FAULT INTERFACE

Solenoid Control	System	Function
Starter Air Valve	Starting	Controls pneumatic power to the Air/Turbine Starter
Overspeed solenoid (fuel shutoff) valve	Thrust Control	Shuts off fuel in overspeed or Thrust Control Malfunction conditions
Directional control valve	Thrust Reverser	Controls hydraulic pressure for the nacelle Thrust Reverser System
Isolation control valve		Isolates hydraulic pressure for the nacelle Thrust Reverser System
Buffer Air Valve	Bearing Cooling and Buffer Air	Controls airflow to bearing compartment seals
No. 3 Bearing damper valve	Lubrication Distribution	Controls oil to the No. 3 Bearing damper
Anti-Ice Valve (AIV)	Cowl Anti-Ice	Controls 6th Stage air to the nacelle inlet
Engine Driven Pump (EDP) depressurization solenoid	Hydraulic	Depressurizes hydraulic system for windmill starts

ENGINE CONTROL SYSTEM – EEC DUAL CHANNEL COMMAND COMPONENTS (1 OF 2)

Torque Motor Control	System	Function
Fuel metering valve	Fuel Distribution	Supplies metered fuel for combustion
Return-to-Tank (RTT) valve		Regulates oil and fuel temperature
LPC stator vane actuator	Variable Stator Vanes (VSV)	Improves compressor efficiency
HPC stator vane actuator		
2.5 bleed actuator	Compressor Bleed	Improves engine start and stability
Variable Oil Reduction Valve	Lubrication	Improves system efficiency
Active Clearance Control (ACC) air valve	Active Clearance Control	Improves engine efficiency
Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV)	Lubrication Distribution	Regulates oil and fuel temperature

ENGINE CONTROL SYSTEM – EEC DUAL CHANNEL COMMAND COMPONENTS (2 OF 2)



ENGINE CONTROL SYSTEM OPERATION

ENGINE CONTROL SYSTEM (Cont.)

Data Storage Unit (DSU)

Purpose:

LRU

The DSU is the master source for engine identification, history, and ratings data.

Location:

The DSU is attached to a lanyard that is bolted to the fan case on the J99 electrical connector, located at the top right side of the EEC housing next to Channel A electrical connectors.

Description:

The DSU provides 8 megabytes of Non Volatile Memory (NVM) storage. It can be programmed and erased. Both EEC channels can access the DSU plug, and will access DSU data even if one channel's control processor has failed.

The DSU stores the following data as a minimum on each of the two EEC channels:

- engine configuration and identification
- usage and exceedance historical data
- thrust ratings
- fan trim balance.

When the memory section is full, newer data overwrites older data. The DSU can be verified by an external source, for example, Ground Support Equipment (GSE).

Engine Configuration and Identification

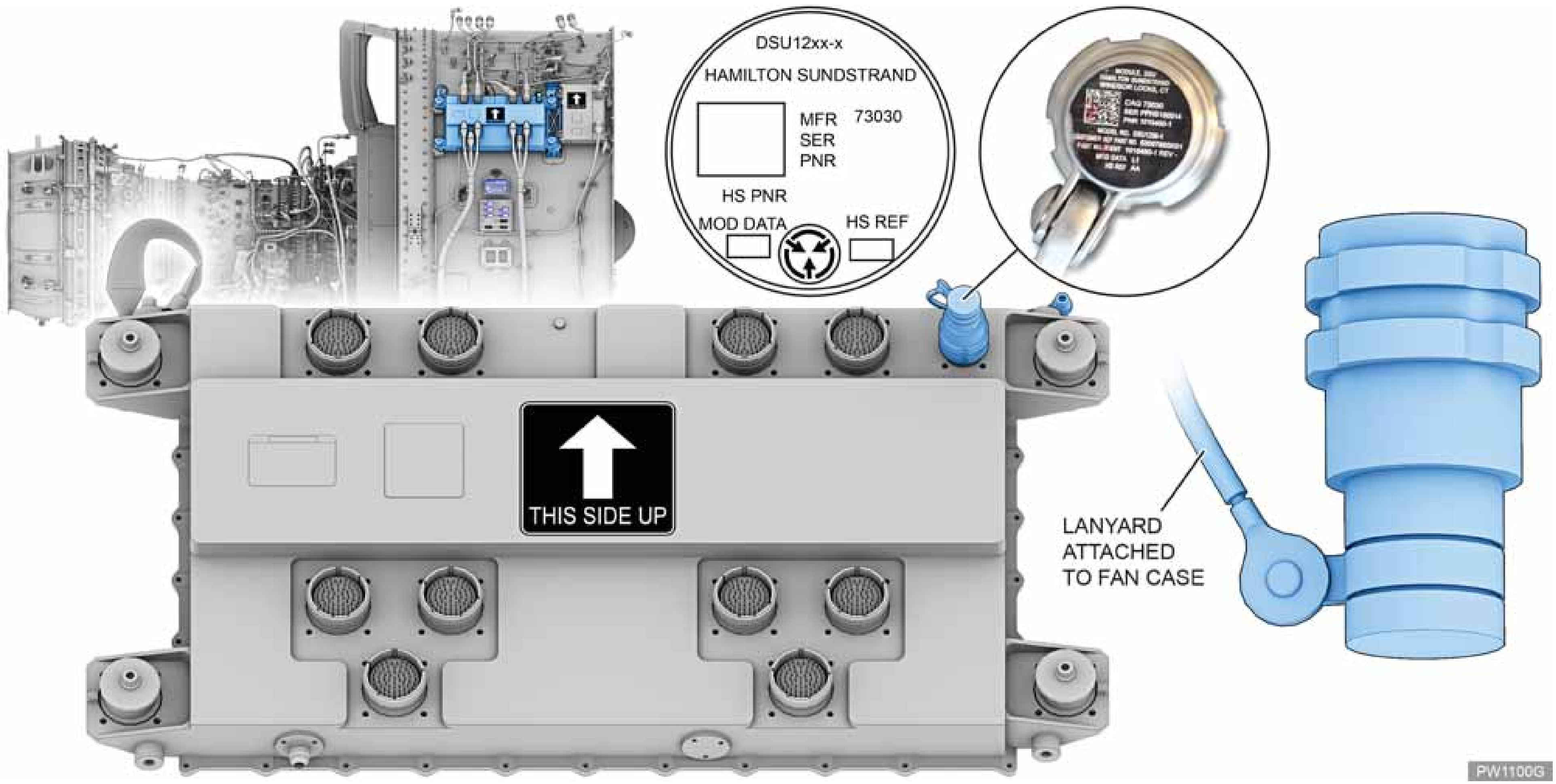
Engine configuration and identification is programmed in the DSU during production acceptance testing. The DSU remains with a specific engine for the life of that engine.

Identification data for the engine can be transferred from the DSU to a new EEC if the old one needs to be replaced. The EEC will be replaced in the following conditions:

- both channels detect a mismatch between their own identification data in data flash and the DSU identification data
- a single channel detects a mismatch of identification data and the other channel has failed the integrity check of its own identification data in EEC data flash.

In the case of a ratings table mismatch, the EEC will send a no-dispatch indication to the ECAM, displaying this message:

ENG x FADEC SYS FAULT



ENGINE CONTROL SYSTEM – DATA STORAGE UNIT (DSU) (1 OF 2)

ENGINE CONTROL SYSTEM

Data Storage Unit (DSU)

Description (Cont.):

Identification Data Acquisition and Validation

Identification data is read from the DSU during EEC initialization. Stored data has three sources: DSU memory, and two separate data flashes for channels A and B.

During initialization, each channel performs an integrity check on the engine identification data in the DSU and in its own data flashes. Engine Identification data is cross-checked during initialization between the EEC channel data flashes, and between each channel's data flash and the DSU master source.

Data Processing

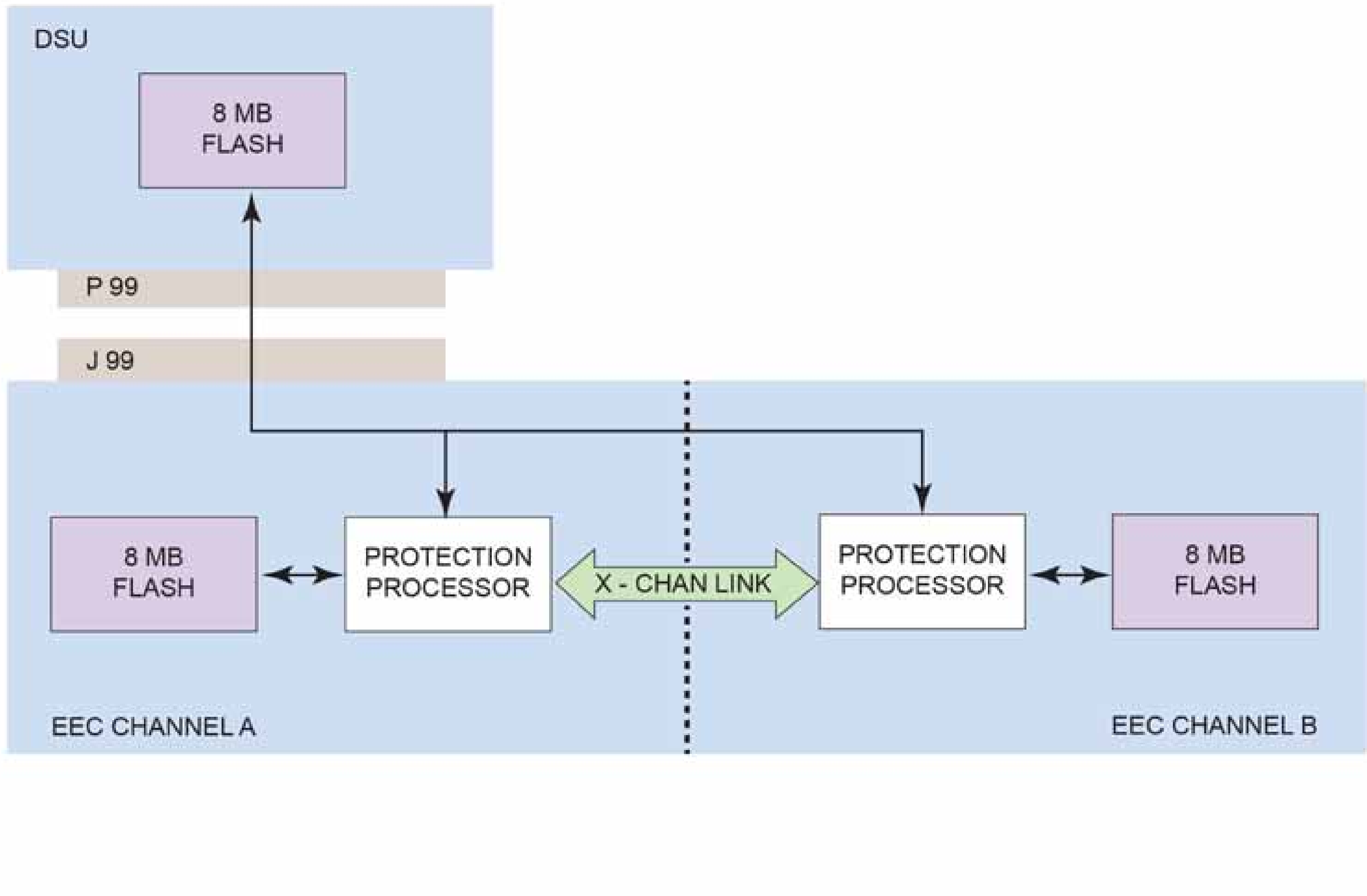
Both EEC channels will read DSU inputs during initialization, but will only synchronize engine usage, exceedance, and fault data into the EEC memory when all of the following are true:

- aircraft is on the ground
- engine is not running
- both channels detect EEC replacement (that is, the engine aircraft type in the EEC does not match the DSU aircraft type).

In the case of a ratings table mismatch, the EEC will send a no dispatch indication to the ECAM (ENG x FADEC SYS FAULT).

The data in the table below is stored in a write-protected area.

Data	Example
DSU hardware part number	5306766
DSU data part number	5325246-08
Engine serial number	770XXX
Engine nameplate	PW1127G-JM
Engine Name Plate Index	27K
N1 modifier	D: -57 C: -36 B: -39 A: -27



ENGINE CONTROL SYSTEM – DATA STORAGE UNIT (DSU) (2 OF 2)

ENGINE CONTROL SYSTEM

Data Storage Unit (DSU)

Description:

Data Processing (Cont.):

Thrust Ratings Data and Schedules

The DSU stores the following thrust rating data and schedules:

- Max Continuous Takeoff (MCTO) rating and derates
- Go-around flat day rating
- Reverse rating
- Max Continuous (CT) rating
- Max Climb (CL) rating
- Burner Pressure (Pb) minimum schedules
- N1 idle schedules
- ITT (EGT), N1 and N2 redlines.

The table at right shows thrust ratings for each aircraft. The last two numbers in each engine designation indicate certified thrust rating.

Thrust Rating	
Engine Designation	Aircraft
PW1122G-JM	A319neo
PW1124G-JM	
PW1127G1-JM	
PW1124G1-JM	A320neo
PW1127G-JM	
PW1127GA-JM	
PW1127G1-JM	
PW1129G-JM	
PW1130G-JM	A321neo
PW1133G-JM	
PW1133GA-JM	
PW1133G1-JM	
PW1135G-JM	

ENGINE CONTROL SYSTEM

Data Storage Unit (DSU)

Description (Cont.):

Downloading

DSU data is available for download through the aircraft using the interactive mode of the Centralized Fault Display System (CFDS), which includes the Last Leg Report, Ground Report, and LRU Identification Report.

A DSU download includes the following data, selected by the CFDS and stored in separate DSU memory regions for channels A and B:

- engine snapshot data, for example, faults and exceedances
- transient recordings data.

A Non Volatile Memory download is only available when the aircraft is on the ground, the EEC is in interactive mode, and the rotor is not spinning.

The table at right indicates data storage type and placement area on the DSU.

Data Storage Locations		
Channel	Designation	Block
A	• Fault snapshots • Exceedance snapshots • Engine event snapshots • Engine event transient data	• Operating system reserved section • Engine usage historical data
B		• PHMU fan trim balance • Ratings • Engine identification

ENGINE CONTROL SYSTEM

Data Storage Unit (DSU) (Cont.)

Operation:

The DSU must be installed before the engine can start. If the DSU becomes disconnected in flight, the EEC will use the programming information stored in its memory for continued operation.

The engine serial number is input via the DSU for use with the engine condition monitoring program. Data for reprogramming the DSU can be downloaded through the aircraft's Central Maintenance Computer (CMC) or a Common Engine Software Loader (CESL).

ENGINE CONTROL SYSTEM (Cont.)

Common Engine Software Loader (CESL)

The Common Engine Software Loader is a kit used to test, update, or reprogram the components below:

- Electronic Engine Control, referred to in this case as the Full Authority Digital Electronic Control (FADEC)
- Prognostics and Health Management Unit (PHMU).

CESL can also read and write information to the Data Storage Unit (DSU).

CESL is a suitcase-style instrument kit consisting of a Yuma® tablet programming device, internal power supplies, a DSU test port, cable test ports, and two interface cables to connect to the communication ports and power inputs.

CESL is equipped with wheels and a handle for rolling. Carrying the unit is not recommended.

For CESL operation instructions, refer to Service Bulletin PW1000G-C-73-00-0003-00A-930A-D.

COMMON ENGINE SOFTWARE LOADER (CESL)

ENGINE CONTROL SYSTEM (Cont.)

Yuma Tablet

A handheld computer called a Yuma® tablet is paired with a specific CESL unit. The software is tested, updated, or reprogrammed using a series of menu options, and saved to file folders on the tablet.

Menus and their functions are listed in the table.

Menu Options	Function
FADEC Reprogramming	Update FADEC software
PHMU Reprogramming	Update PHMU software
DSU Reprogramming	Test or reprogram DSU software
Maintenance Menu	Display Secure Digital card code, reports and maintenance information


YUMA 2
PRATT AND WHITNEY
A United Technologies Company
FADEC
Reprogramming
PHMU
Reprogramming
DSU
Reprogramming
Maintenance
Menu
OK
Fn
F1
F2
F3
Trimble
C. Generic

YUMA® TABLET

ENGINE CONTROL SYSTEM (Cont.)

Ambient Pressure (Pamb) Sensor

Purpose:

LRU PMT

The Pamb sensor is a single-channel probe that detects ambient air pressure.

Location:

The Pamb sensor is internal to the EEC housing and is located on the bottom right side below the Channel A electrical connectors.

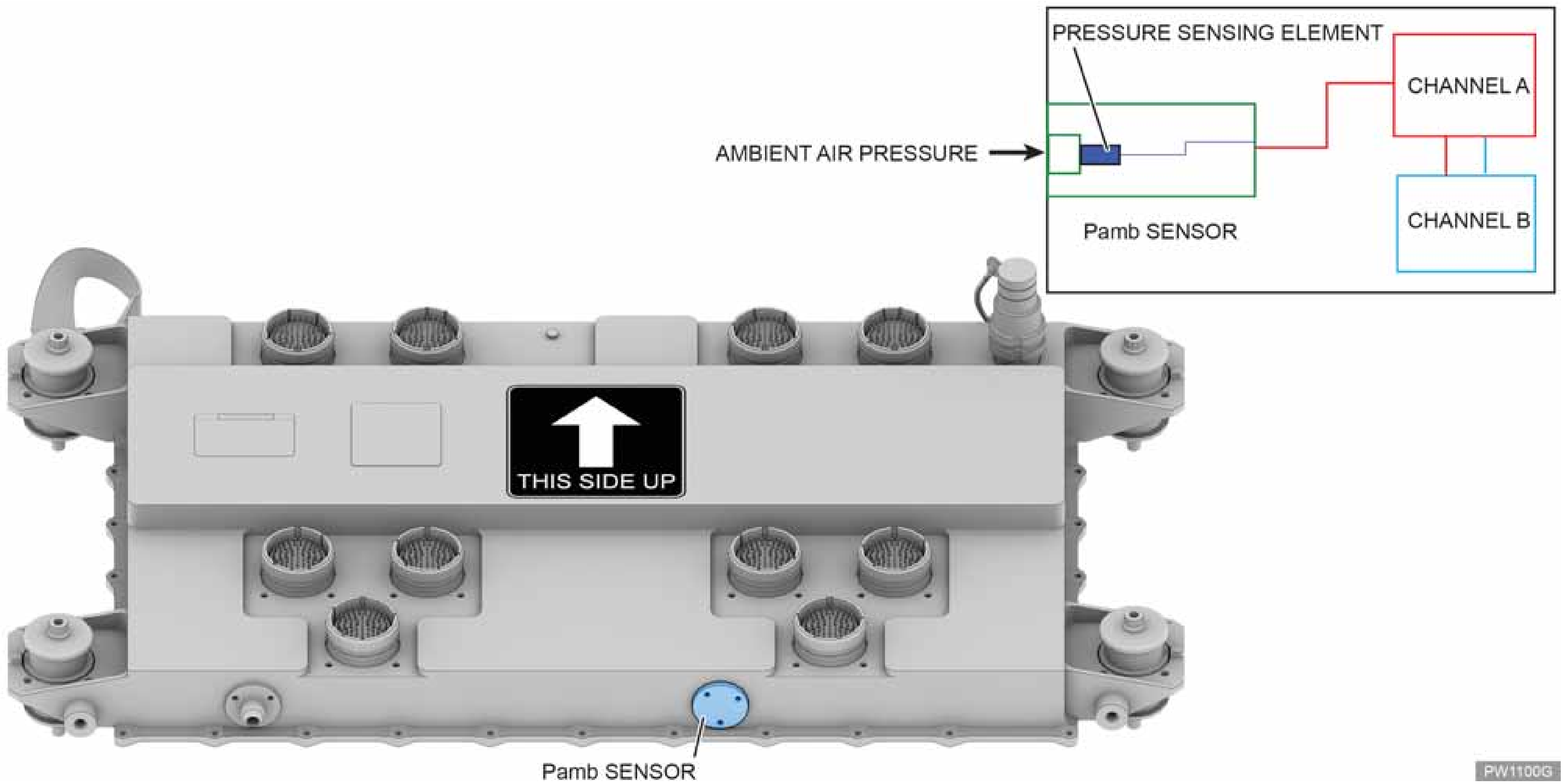
Description:

The sensor is wired to Channel A and detects ambient air pressure through a port in the EEC housing.

Operation:

When pressure is applied, a strain gauge alters its resistance, changing output voltage to the sensor in direct correlation to ambient air pressure. Ambient air pressure is used by the EEC for many control scheduling functions, including engine rating and Mach number calculations.

The EEC also compares its Pamb signal with an independent ambient pressure signal from the aircraft to validate the health of each one.



ENGINE CONTROL SYSTEM – AMBIENT PRESSURE (Pamb) SENSOR

ENGINE CONTROL SYSTEM (Cont.)

PS14 Sensor

Purpose:

The PS14 sensor detects air pressure at the fan exit.

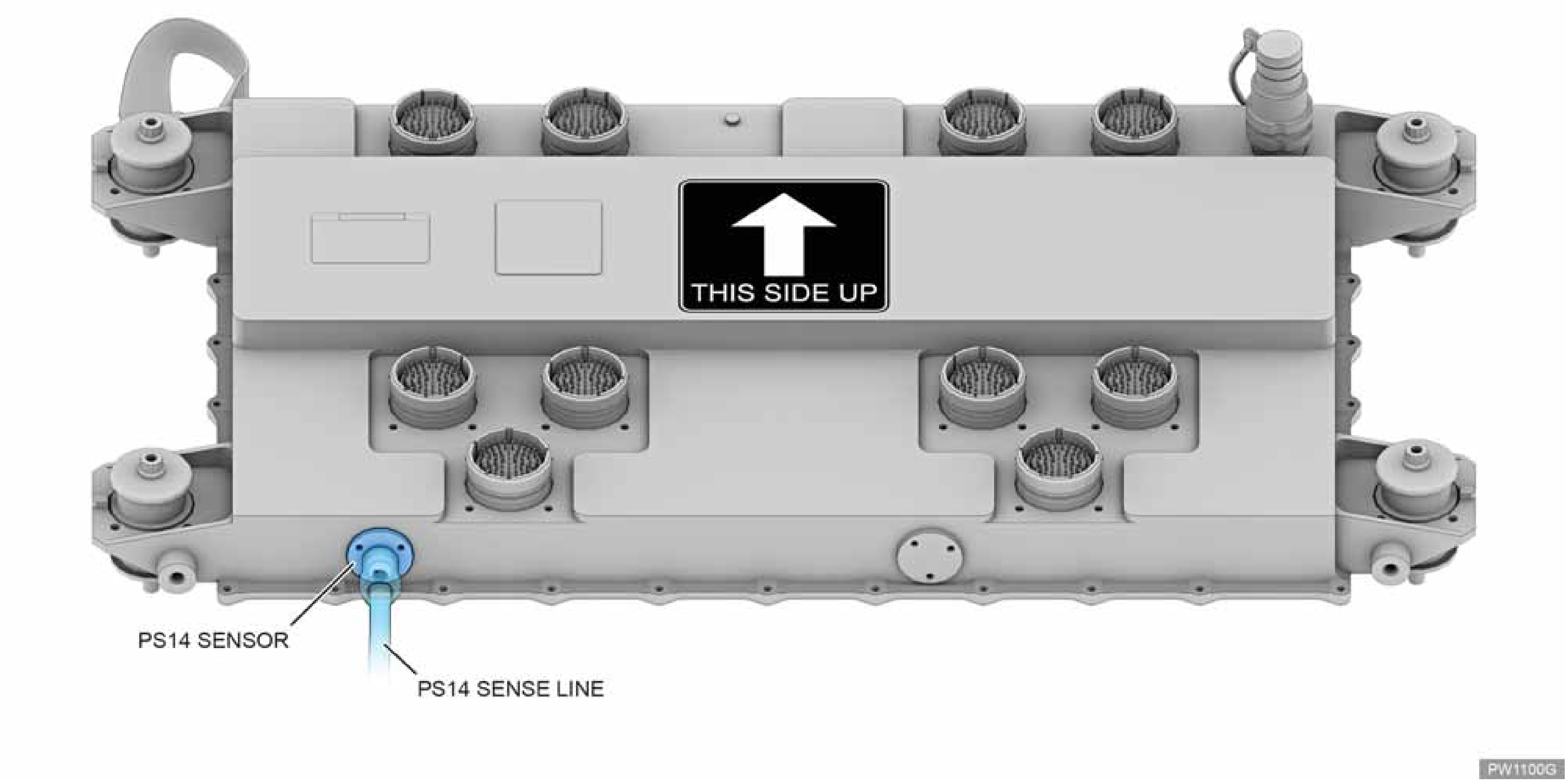
Location:

The PS14 sensor is internal to the EEC, located on the bottom left of the EEC housing below the Channel B electrical connectors.

The PS14 sense line attaches to the PS14 sensor at the rear fan case support at 3:30.

Description:

The single-channel sensor wired to Channel B detects fan exit air pressure through an external sense line. The inlet port for the PS14 sense line is a plenum covered by a fan case liner between two fan exit guide vanes. The plenum receives air pressure from unsealed locations aft of the fan exit guide vanes.



ENGINE CONTROL SYSTEM – FAN EXIT AIR PRESSURE SENSOR (PS14) INLET PORT

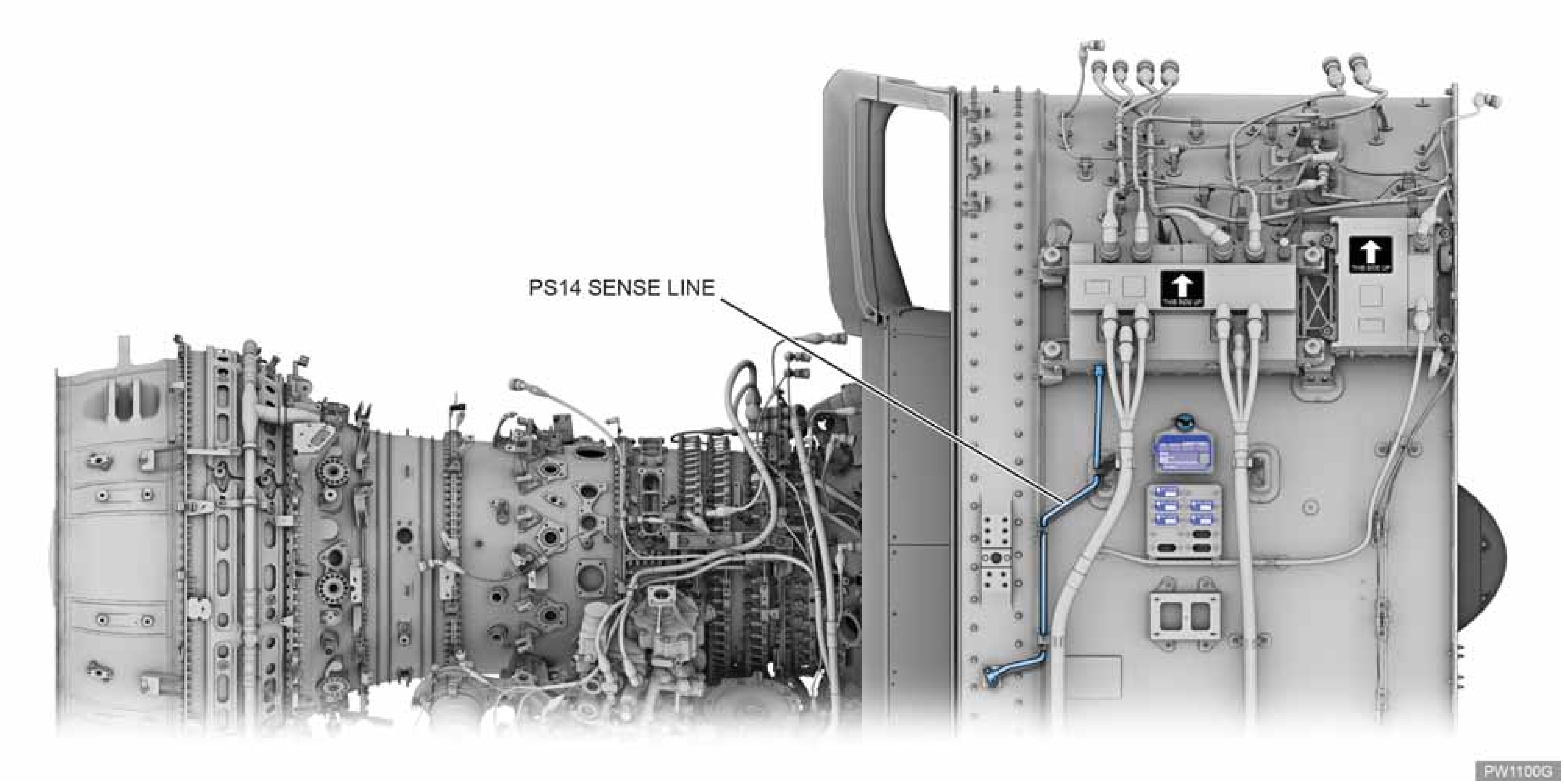
ENGINE CONTROL SYSTEM

PS14 Sensor (Cont.)

Operation:

When pressure is applied, a strain gage alters its resistance, changing output voltage to the sensor. The output voltage correlates directly to air pressure.

Fan exit pressure is used by the EEC to calculate engine inlet air pressure (P2) and to validate an independent air pressure reading from the aircraft.



ENGINE CONTROL SYSTEM – FAN EXIT AIR PRESSURE SENSOR (PS14) EXTERNAL SENSE LINE

ENGINE CONTROL SYSTEM (Cont.)

T2 Sensor

Purpose:

LRU PMT

The T2 sensor detects engine inlet air temperature at Station 2, used for many control scheduling functions, including engine rating and Mach number calculations.

Location:

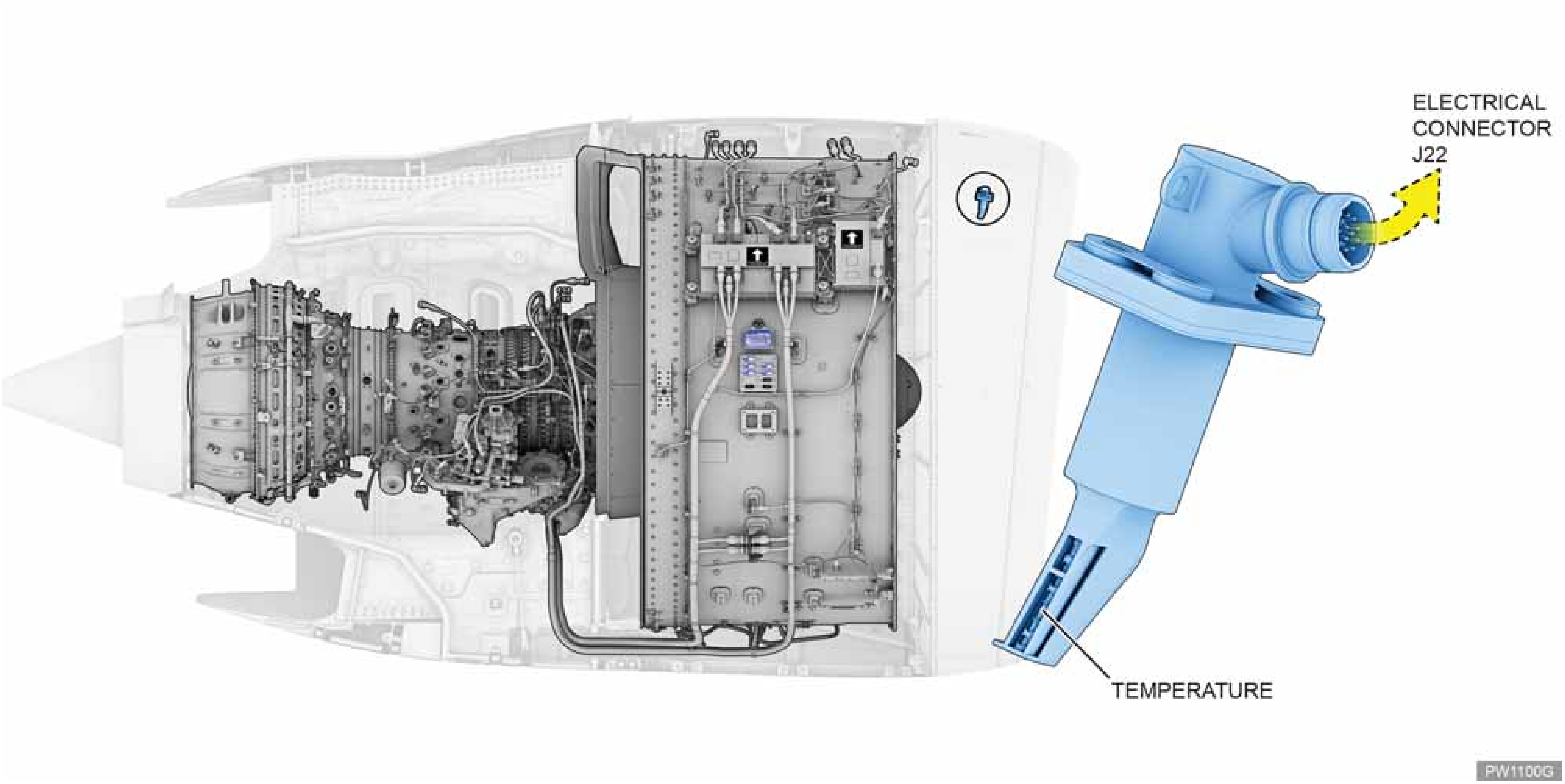
The sensor is located on the inlet cowl at 1:00.

Description:

The dual channel sensor uses a single-element Resistance Temperature Detector (RTD) that detects air temperature in the fan inlet. Resistance of the sensing element alters in response to a change in the surrounding air temperature. The constant relationship means a properly functioning sensor will always indicate the same resistance at any one temperature.

Operation:

The sensing element is connected to an electrical connector that transmits the temperature signal to the EEC. The EEC processes the sensor signal and also receives a total air temperature signal from the aircraft's Air Data Inertial Reference Unit (ADIRU). The EEC compares the two inlet air temperature signals to validate the health of each signal.



ENGINE CONTROL SYSTEM – STATION 2 TEMPERATURE (T2) SENSOR

ENGINE CONTROL SYSTEM (Cont.)

T3 Sensor

Purpose:

LRU PMT

The T3 sensor supplies Station 3 temperature data to the EEC for monitoring engine performance and High Pressure Compressor health.

Location:

The T3 sensor is secured to the diffuser case at 1:00.

Description:

The dual-channel sensor consists of a housing, a K-type thermocouple and a terminal assembly. It has a welded and brazed construction. The sensor transmits its analog signals to the EEC through the WC05 harness assembly.

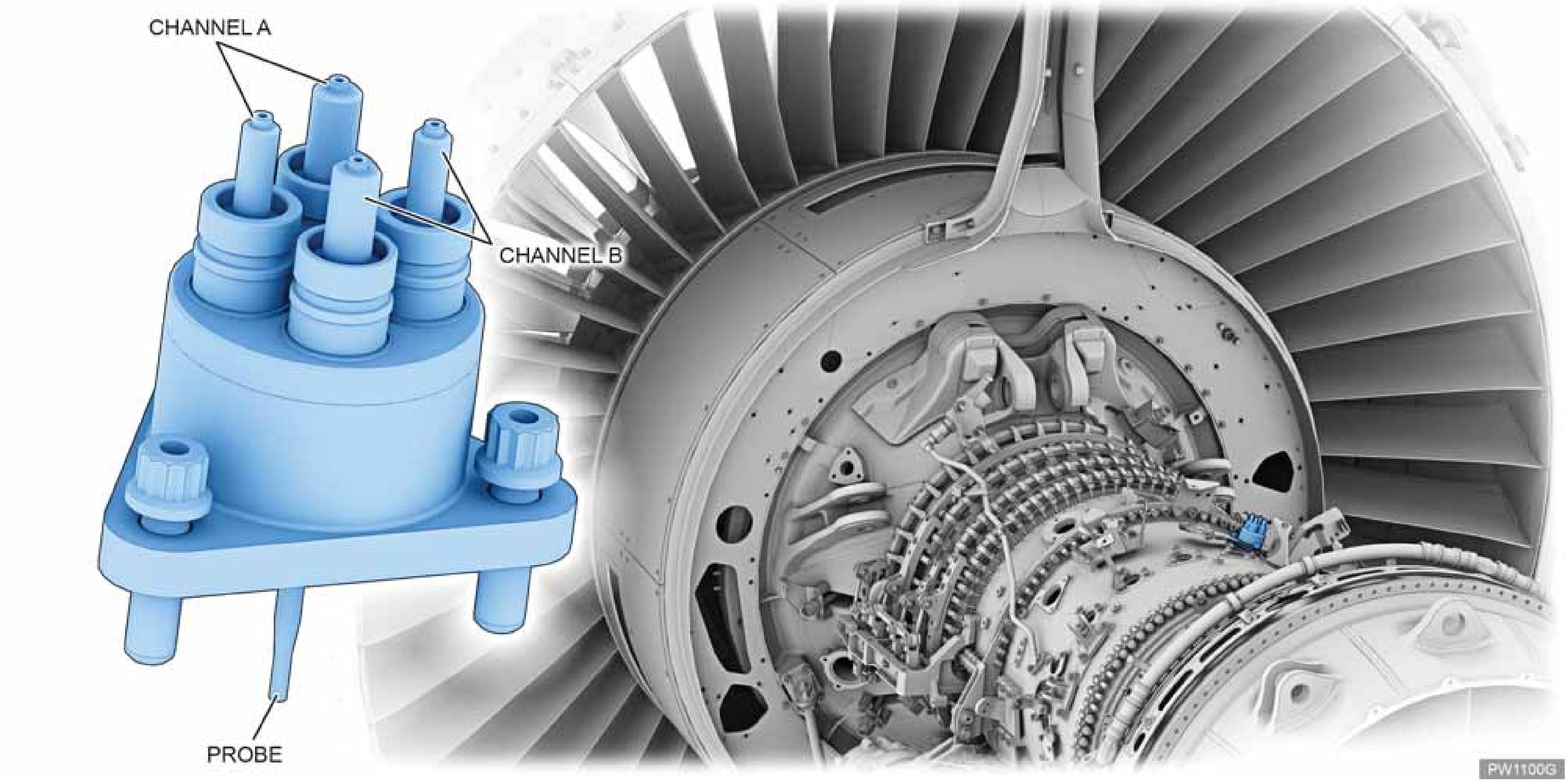
Operation:

One set of terminal studs sends the signal to Channel A, and the other set sends the signal to Channel B.

Safety Conditions

CAUTION

DO NOT TORQUE THE STUD NUTS MORE THAN THE SPECIFIED TORQUE. IF YOU DO, YOU CAN BREAK OR DAMAGE THE STUDS.



ENGINE CONTROL SYSTEM – STATION 3 TEMPERATURE (T3) SENSOR

ENGINE CONTROL SYSTEM (Cont.)

P2.5/T2.5 Probe

Purpose:

LRU PMT

The P2.5/T2.5 probe provides Station 2.5 pressure and temperature information to the EEC.

Location:

The probe is located on the Compressor Intermediate Case at 1:00.

Description:

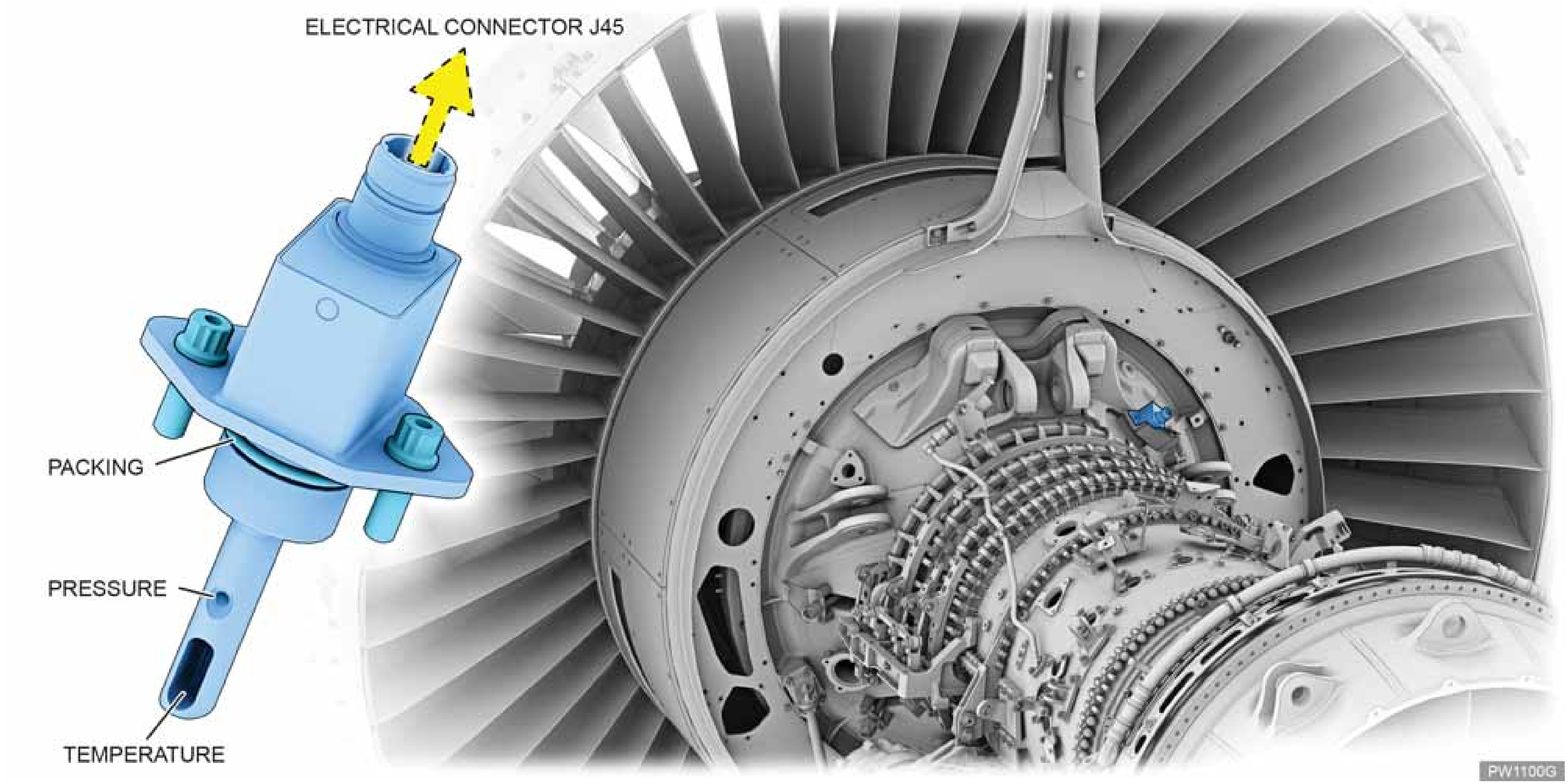
The P2.5/T2.5 probe detects LPC exit air pressure and temperature at Station 2.5.

The probe contains two single-channel sensors. P2.5 is sent to EEC Channel B, and T2.5 is sent to Channel A. The EEC processes both signals to monitor engine health and analyze performance.

The probe consists of a stainless steel housing, an internal strain gauge-type transducer for measuring air pressure, a Resistance Temperature Detector (RTD) sensing element for measuring air temperature, and an electrical connector.

Operation:

The housing of the probe allows inlet air to contact the RTD sensing element. As air pressure is applied, the resistance of the strain gage changes, altering the output voltage in direct correlation. The sensing element is connected to the electrical connector, which transmits the temperature signal to the EEC.



ENGINE CONTROL SYSTEM – P2.5/T2.5 PROBE

ENGINE CONTROL SYSTEM (Cont.)

Burner Pressure (Pb) Sensor

Purpose:

LRU PMT

The Pb sensor provides a burner pressure electrical signal to the EEC for fuel scheduling, surge recovery, stall detection, fuel topping, autostart logic and shaft shear detection.

Location:

The sensor is attached to the Compressor Intermediate Case fire seal at 10:00.

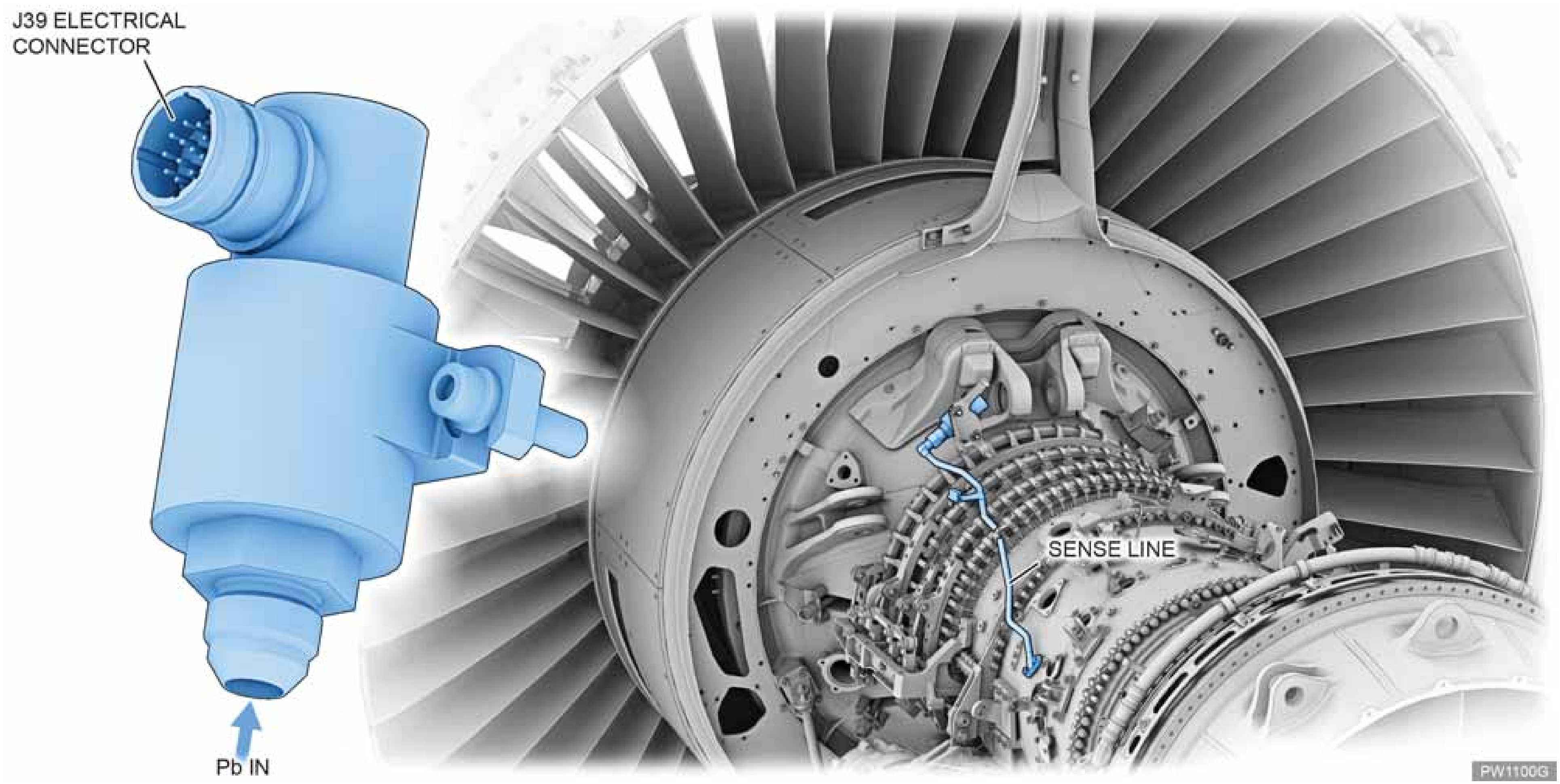
Description:

The sensor is a dual-channel pressure transducer that measures the gas path air pressure in the combustion chamber (Pb) via the Pb sense line.

Operation:

The sensor converts air pressure from the diffuser case into an electrical signal and sends the signal to the EEC.

The EEC processes the signal and uses the gas path air pressure for fuel scheduling, stall detection, auto-start logic, and shaft shear detection.



ENGINE CONTROL SYSTEM – BURNER PRESSURE (Pb) SENSOR

ENGINE CONTROL SYSTEM (Cont.)

Permanent Magnet Alternator (PMA)

Purpose:

LRU PMT

The PMA rotor and stator generator provides electrical power to both channels of the EEC during engine operation.

Location:

The PMA is attached to a dedicated mounting pad on the front left side of the Main Gearbox.

Description:

Rotor

The PMA rotor consists of a high tensile steel magnet and an Inconel® sleeve. The rotor houses the magnets, which are held in place by the sleeve. The rotor is installed on the PMA drive shaft on the Main Gearbox. Removal and installation of the rotor requires special tooling, including:

- PWA211434 puller
- PWA211435 torque adapter.

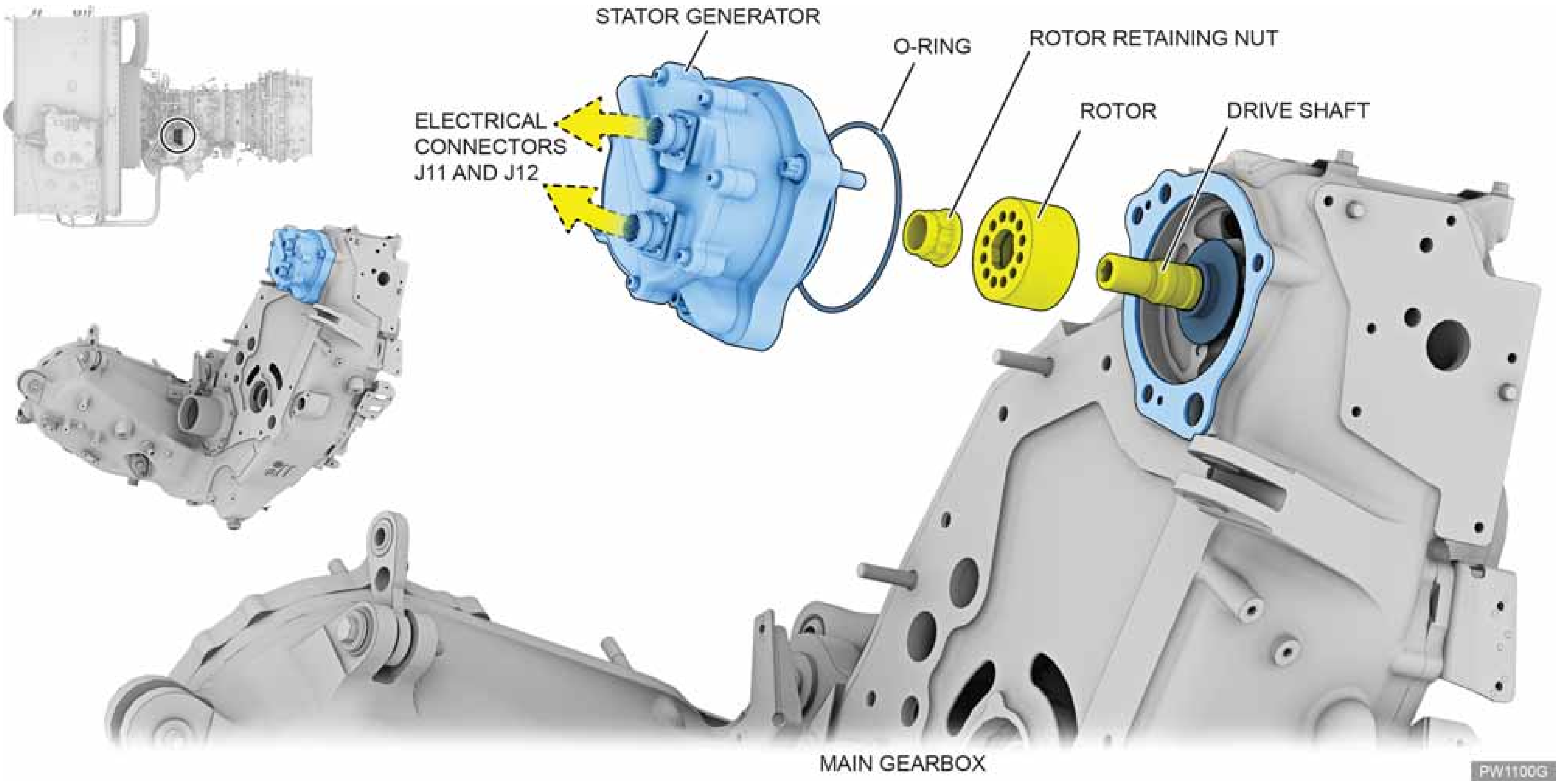
Safety Conditions

CAUTION

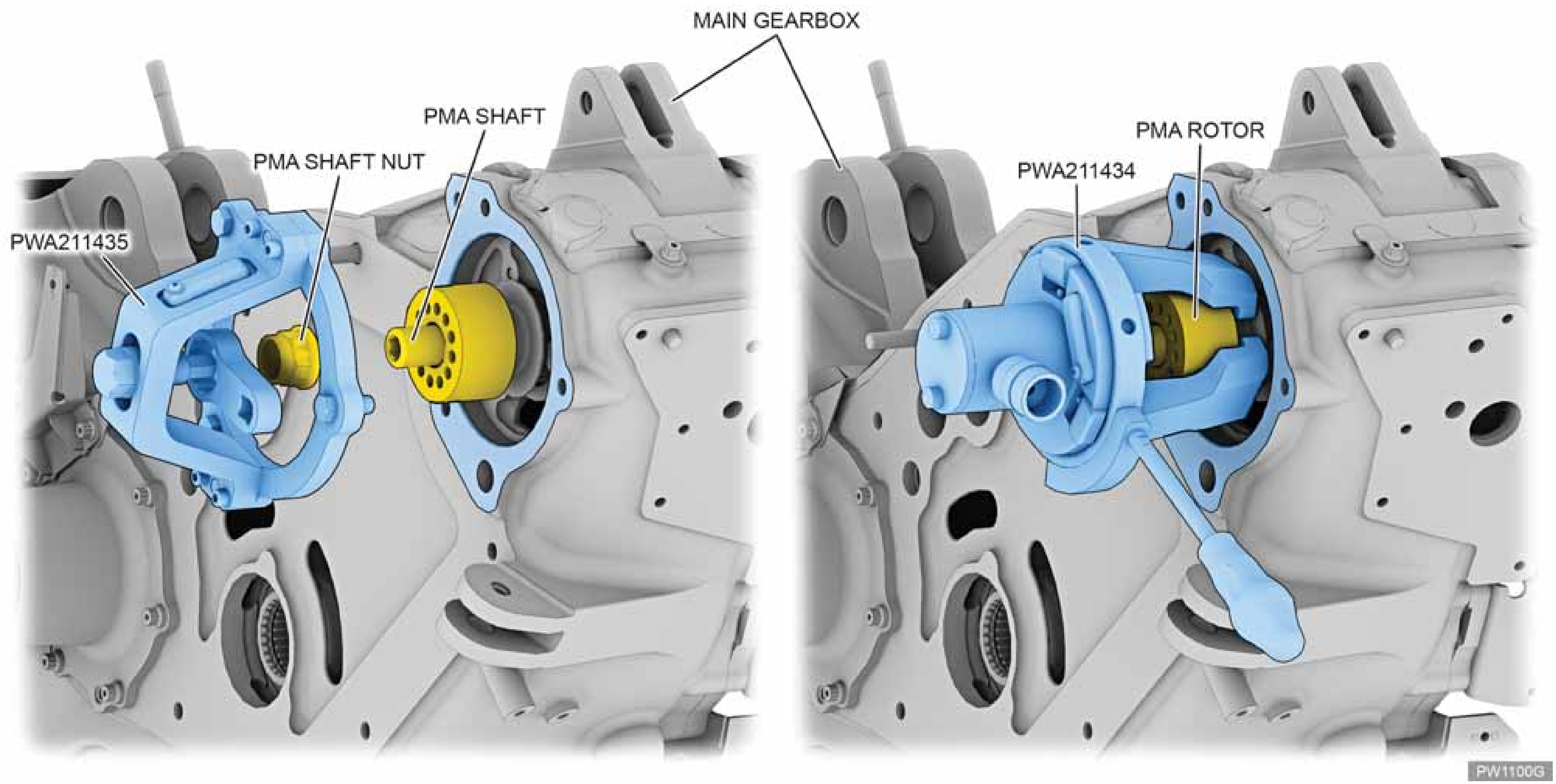
THERE ARE STRONG MAGNETS IN THE ROTOR. MAKE SURE YOU KEEP THE ROTOR AWAY FROM OTHER METAL OBJECTS, PARTICLES, AND DUST. IF YOU DO NOT DO THIS, DAMAGE TO THE ROTOR CAN OCCUR.

Stator

The PMA stator consists of two electrical connectors; three captive fasteners; an O-ring; a face seal; and two sets of single-channel circuit windings contained in an oil-cooled aluminum housing.



ENGINE CONTROL SYSTEM – PERMANENT MAGNET ALTERNATOR (PMA)



ENGINE CONTROL SYSTEM – PERMANENT MAGNET ALTERNATOR REMOVAL TOOLS

ENGINE CONTROL SYSTEM

Permanent Magnet Alternator (PMA) (Cont.)

Operation:

Rotor

The PMA drive shaft transmits torque from the Main Gearbox to the PMA rotor. A self-locking nut is installed to provide axial retention of the PMA rotor. As the rotor is spun by the drive shaft, the magnet rotates and induces a current in both sets of windings of the stator. This current provides the voltage that is used to power the EEC.

Stator

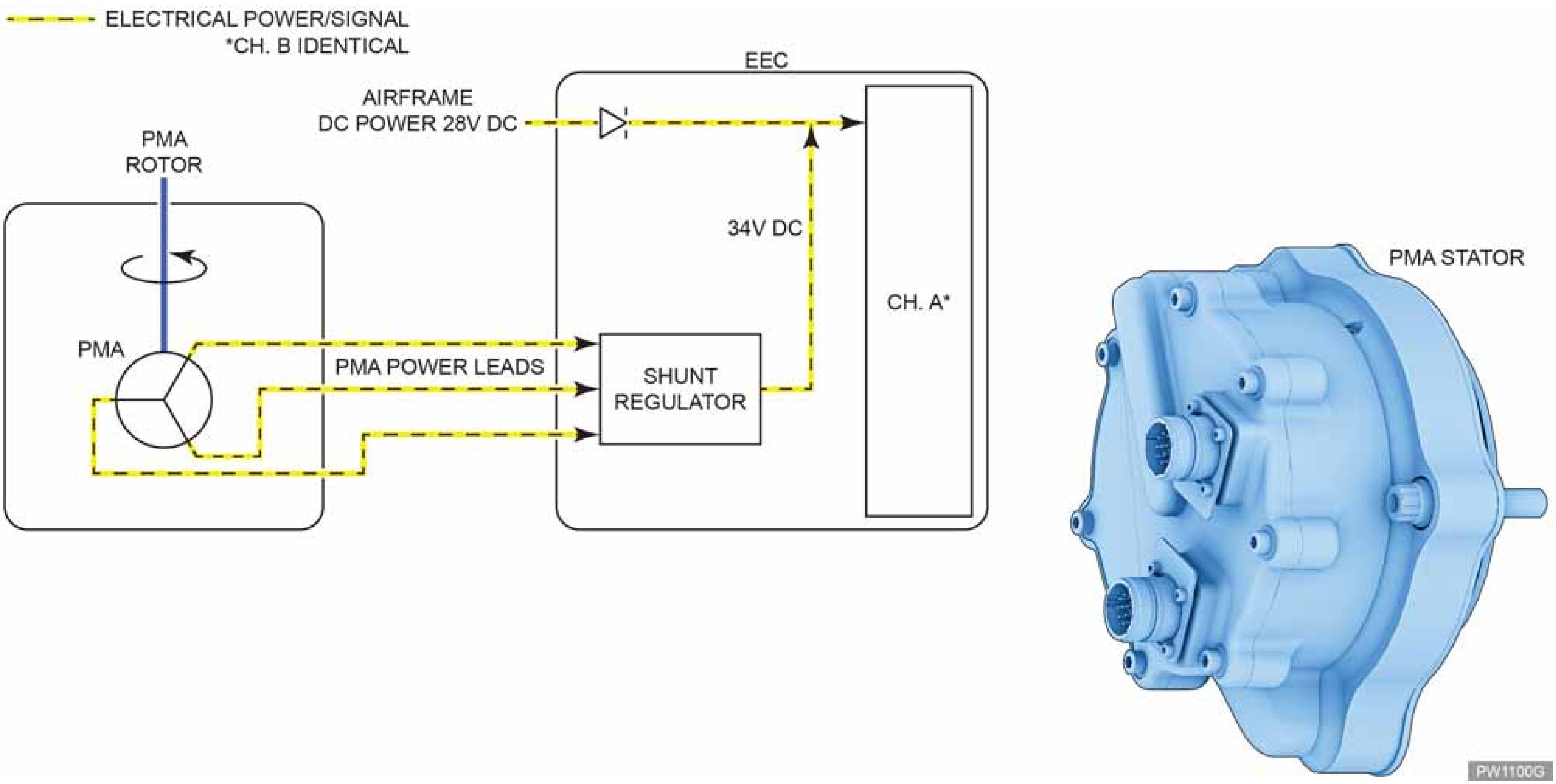
“In” and “out” ports that align with matching holes in the Main Gearbox direct engine oil in and out of the stator housing. Movement of the oil through the housing’s internal passages allows the oil to cool the PMA.

Oil sealing is provided by a face seal at the “in” and “out” holes. The seal is designed for maximum durability. Attachment features of the PMA to the Main Gearbox minimize relative motion between the mating interfaces, assuring that wear of the seal face is not possible.

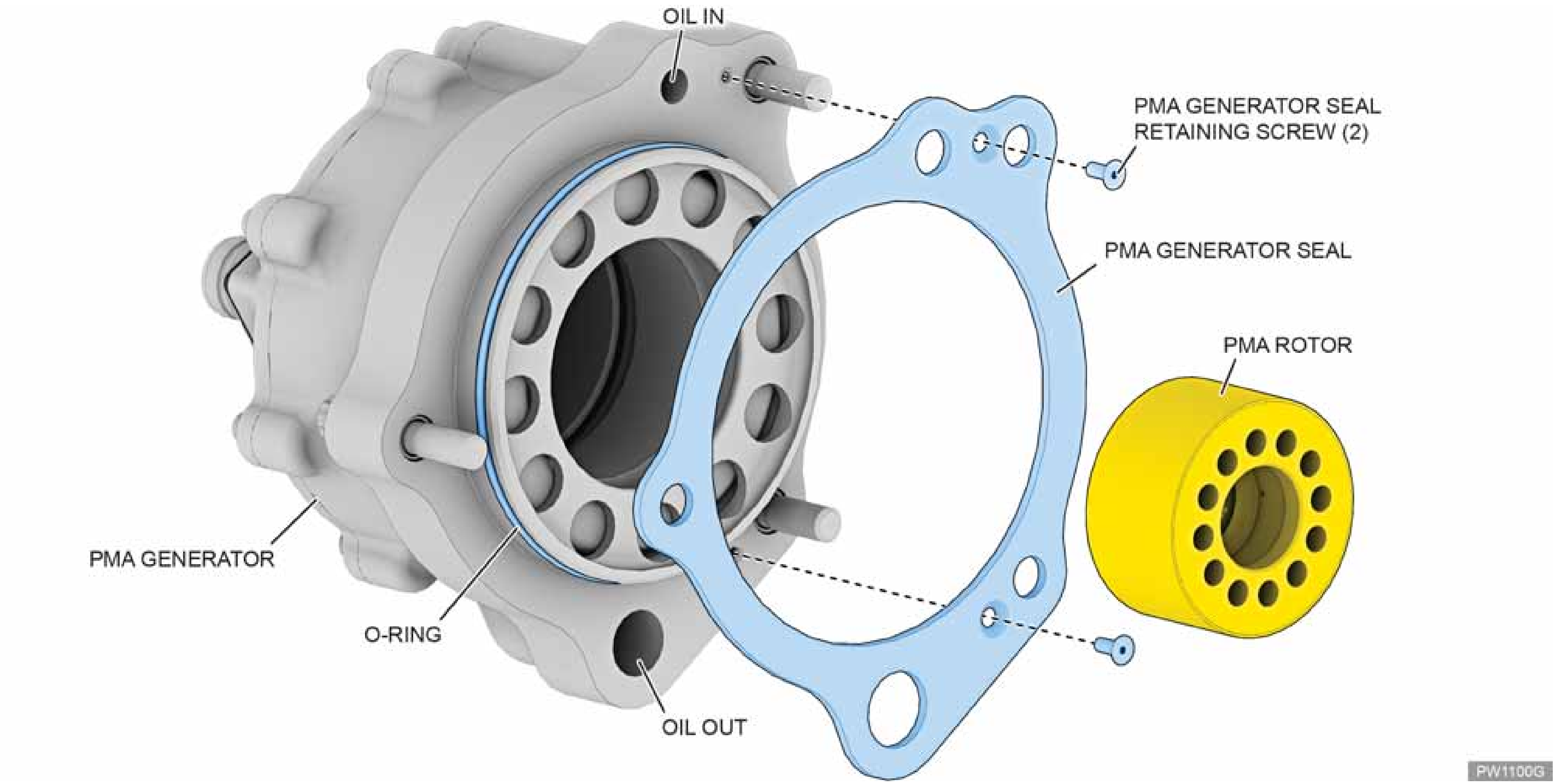
If the PMA becomes inoperable during engine operation, 28V DC aircraft power automatically switches on to provide power to the FADEC System.

The two sets of windings are isolated from each other and are connected to separate Channel A and B electrical connectors on the outside of the PMA stator housing.

An O-ring provides oil sealing between the PMA stator housing and the Main Gearbox. If the PMA is removed on-wing or during a shop visit, the O-ring is replaced.



ENGINE CONTROL SYSTEM – PMA SENSOR SCHEMATIC



ENGINE CONTROL SYSTEM – PERMANENT MAGNET ALTERNATOR (PMA) ROTOR

ENGINE CONTROL SYSTEM (Cont.)

Wiring Harnesses

Purpose:

LRU PMT

Wiring harnesses provide a pathway for electrical commands, for engine and airframe data, and for power between Electronic Engine Control, aircraft, and engine components.

Location:

Harness locations vary as described below.

- Fan case harnesses, designated with the letters *WF*, are attached to the left side of the case.
- Core harnesses, designated as *W* or *WC*, are attached to the left side of the fan case and the left and right side of the engine core.
- A nacelle harness designated as *WN30* is located on the inlet cowl.

Safety Conditions

CAUTION

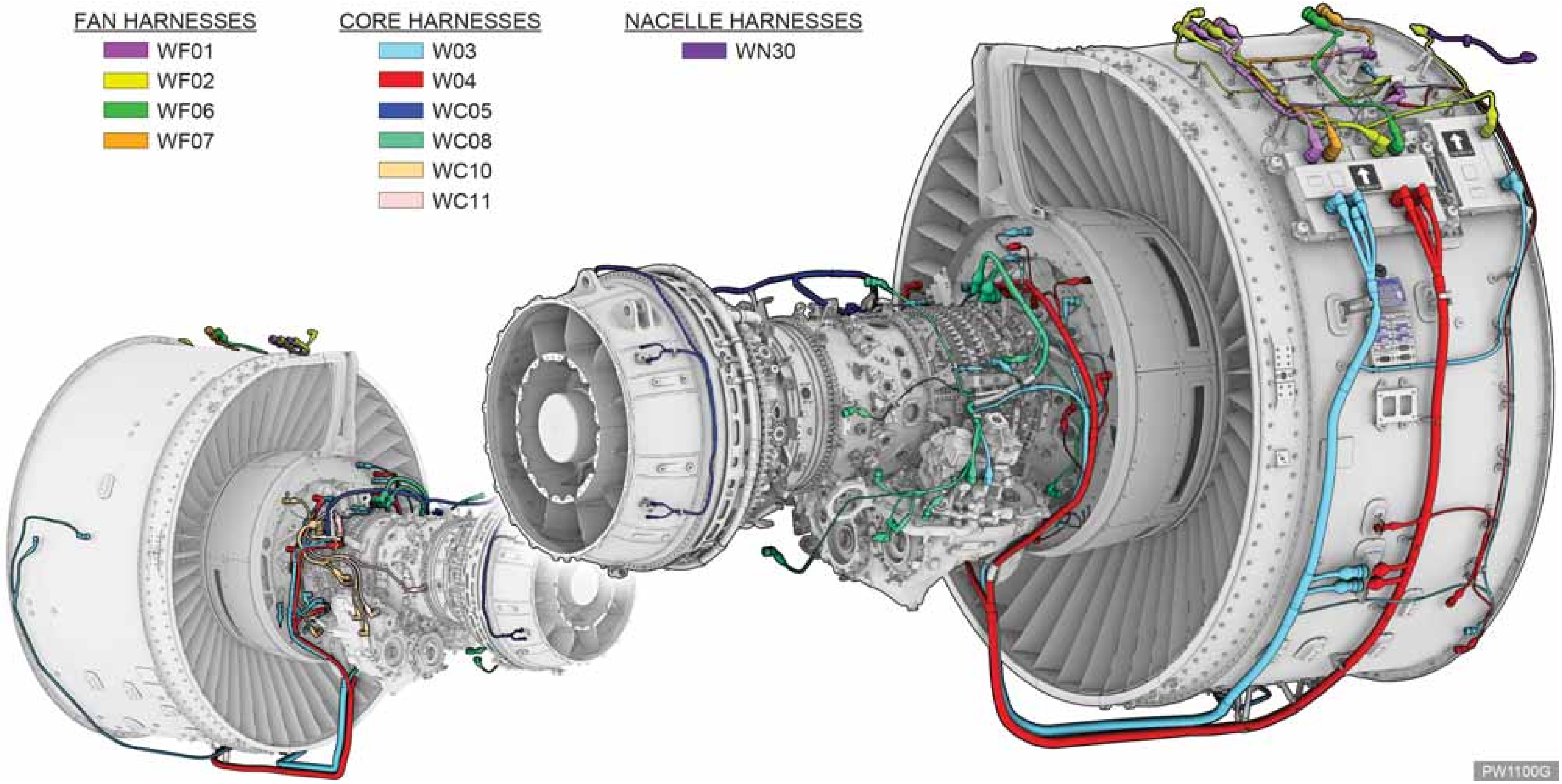
DO NOT BEND OR TWIST THE WIRING HARNESS TOO MUCH. IF YOU DO, DAMAGE TO THE WIRING HARNESS CAN OCCUR.

Description:

Groups of two or three twisted, shielded harness wires are covered in gray, non-flammable, chafe-resistant polyether ether ketone (PEEK) overbraid.

Stainless steel connectors and stainless closed backshells have anti-rotation features.

Harness Type	Designation
Fan case	• WF01, -02, -06, -07
Core	• W03, -04 • WC05, -08, -10, -11
Nacelle	• WN30



ENGINE CONTROL SYSTEM – WIRING HARNESSES

ENGINE CONTROL SYSTEM

Wiring Harnesses (Cont.)

Operation:

Connectors and backshells have 360° shield termination for electromagnetic interference protection.

On-wing harness repair is limited to the polyether ether ketone (PEEK) overbraid. Off-engine repairs can be made by the vendor or an approved Federal Aviation Administration repair facility.

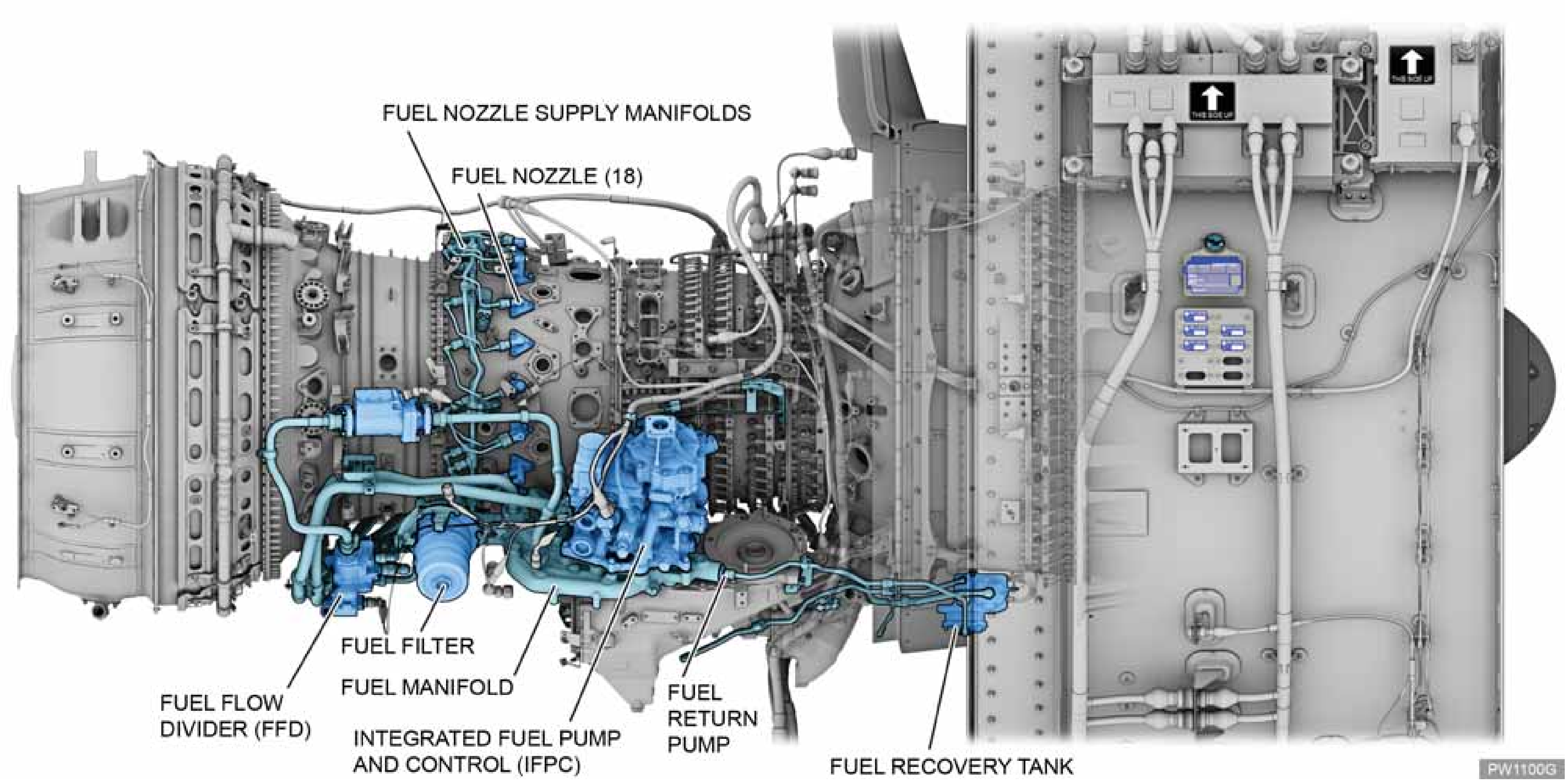
FUEL DISTRIBUTION SYSTEM

The Fuel Distribution System supplies metered, filtered fuel to the engine at the pressure and flow rate necessary to meet all engine operating requirements. The fuel is also heated to prevent ice from clogging the fuel system.

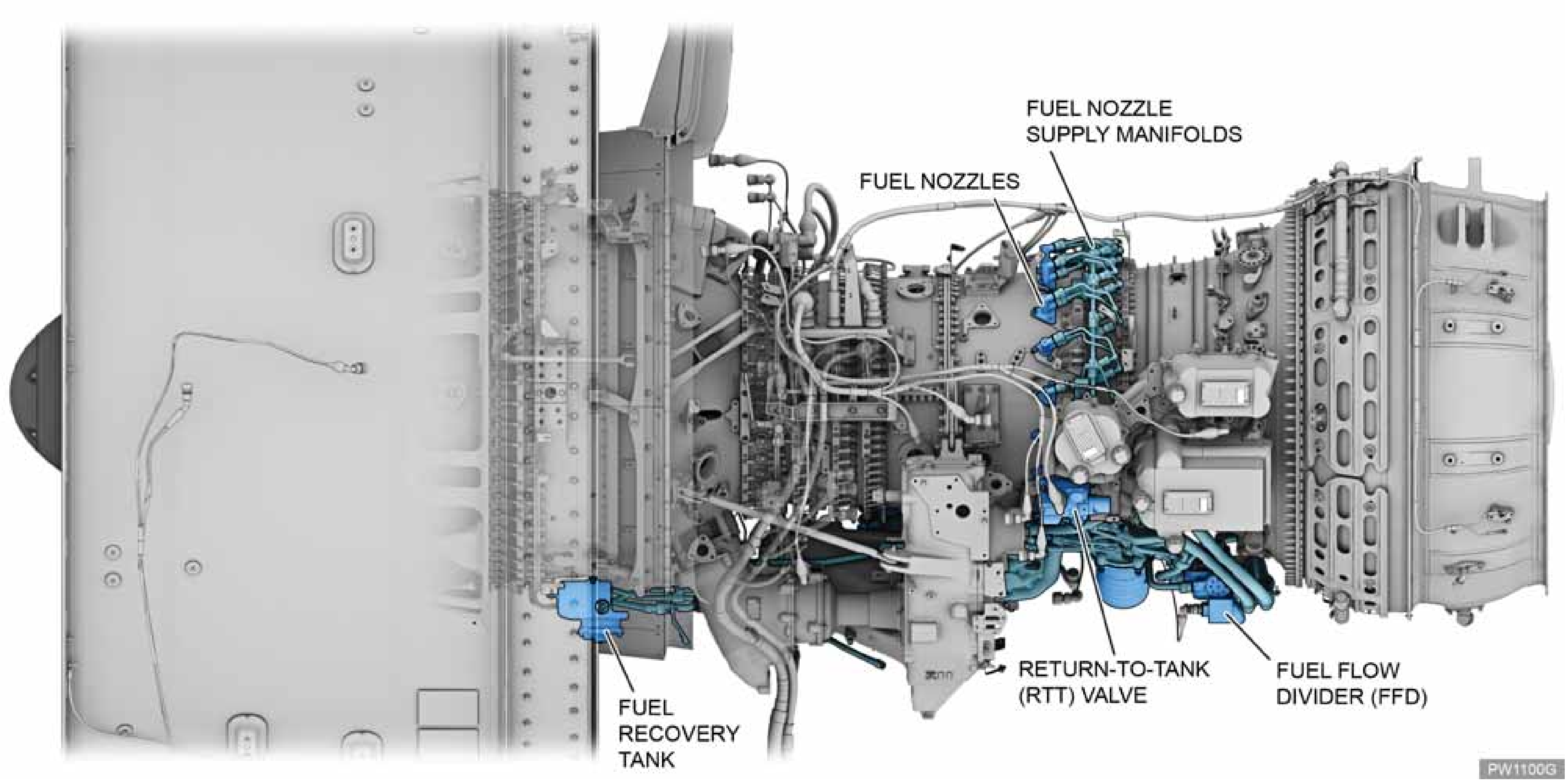
The system supplies metered fuel to the fuel nozzles for combustion, and sends pressurized fuel to engine component actuators for servo pressure.

System components are shown below.

- Integrated Fuel Pump and Control IFPC
- Fuel manifold
- Fuel filter assembly
- Fuel return pump
- Fuel Flow Divider FFD
- Fuel nozzle (18)
- Fuel nozzle supply manifolds
- Fuel recovery tank (Ecology tank)
- Return-To-Tank (RTT) valve



FUEL DISTRIBUTION SYSTEM – RIGHT SIDE



FUEL DISTRIBUTION SYSTEM – LEFT SIDE

FUEL DISTRIBUTION SYSTEM (Cont.)

Integrated Fuel Pump and Control (IFPC)

Purpose:

LRU PMT

The IFPC supplies metered fuel flow to the engine as scheduled by the EEC, and supplies pressurized fuel to engine component actuators.

Location:

The IFPC is attached with bolts to the fuel manifold on the right side of the Main Gearbox at 3:00.

Description:

The IFPC's internal fuel pumping section is comprised of single-stage boost, main, and servo pumps. The boost pump is an impeller and the main and servo pumps are gear pumps.

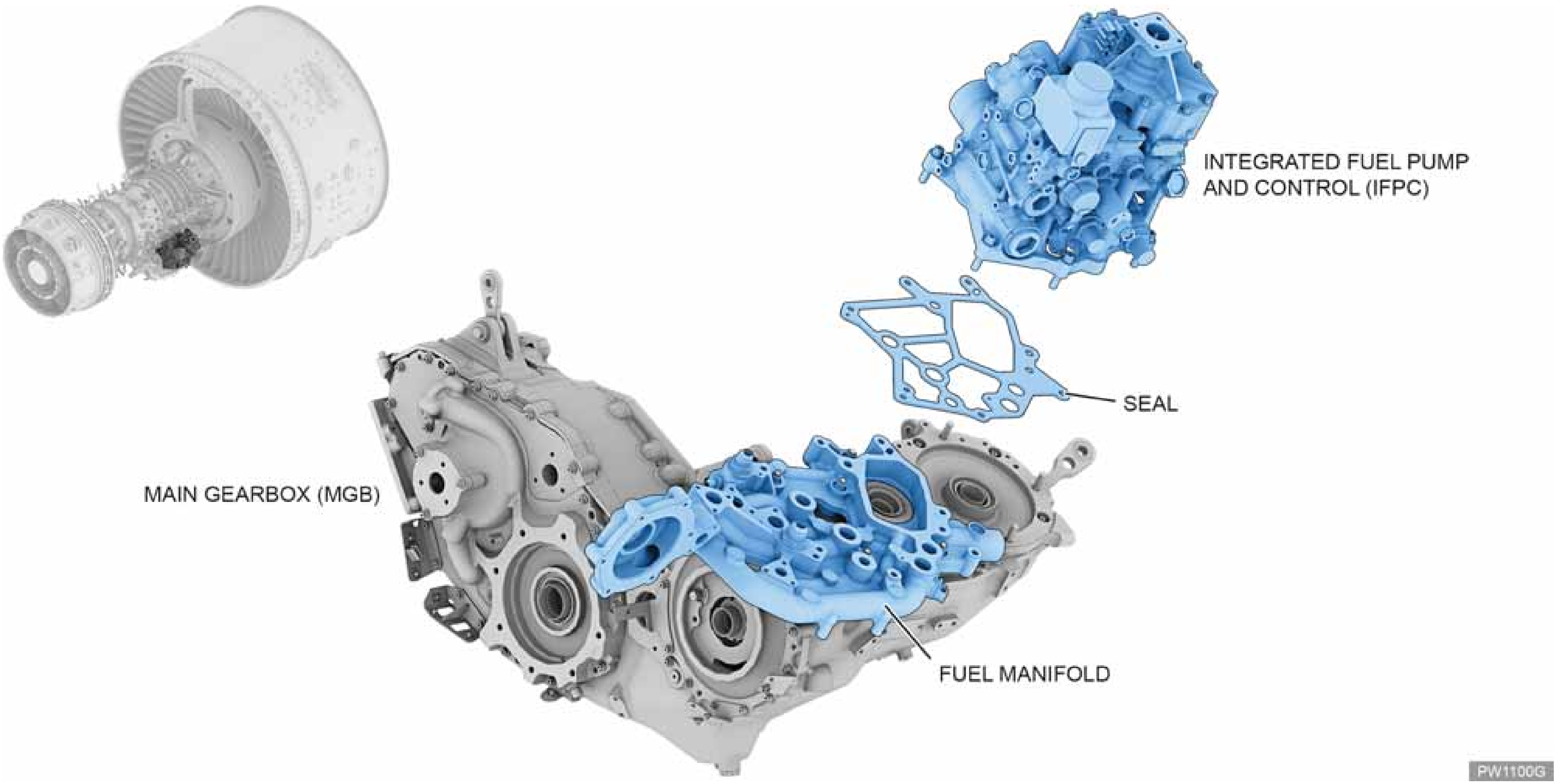
Dual-channel torque motors for the fuel metering valve and the Linear Variable Differential Transformer (LVDT) are contained within the IFPC housing, as are the torque motor for the shutoff valve and the valve's two proximity sensors. The components are wired internally to two electrical connectors on the IFPC, one for each of the EEC channels.

Fuel from the boost pump provides initial pressurization of fuel received from the aircraft tank. Fuel is sent in two directions to the fuel return pump and to the heat exchanger manifold.

The single-stage main pump further increases fuel pressure and directs the pressurized fuel to the metering valve within the fuel control section of the IFPC.

The servo pump further increases the fuel pressure, directing the pressurized fuel through a wire mesh wash filter. Then it sends the fuel on to five engine component actuators, where it is used as muscle pressure to move the actuator pistons.

The main and servo pumps each have pressure relief valves that limit the developing absolute pressure to a pre-set design value. The valves are spring-loaded closed, opening when fuel pressure exceeds a predetermined limit. Fuel that flows past the pressure relief valves bypasses the fuel pump exit and is recirculated back to the fuel filter.



FUEL DISTRIBUTION SYSTEM – INTEGRATED FUEL PUMP AND CONTROL (IFPC)

FUEL DISTRIBUTION SYSTEM

Integrated Fuel Pump and Control (IFPC) (Cont.)

Operation:

1. Fuel from the main pump is directed to the fuel metering valve within the IFPC. The fuel metering valve is a spring-loaded spool valve assembly that controls the flow of fuel to the combustor. The EEC commands the position of the fuel metering valve through a dual-channel torque motor, supplying the correct amount of fuel for engine operation. A dual-channel LVDT provides feedback to the EEC on fuel metering valve position.
2. Downstream of the fuel metering valve is a Pressure Regulating Valve (PRV) and a fuel shutoff valve. The fuel shutoff valve is controlled by a dual-channel torque motor. The PRV is a spring loaded spool valve that keeps a constant fuel pressure drop across the fuel metering valve by changing the amount of fuel returned to the fuel pump. The constant pressure drop across the fuel metering valve ensures that the correct scheduled fuel flow is supplied to the engine. The torque motor controls the fuel pressure to the back side of the PRV and to the fuel shutoff valve.
3. Controlling the fuel pressure to the back side of the PRV causes the PRV to modulate fuel flow between the fuel metering valve and the fuel pump. Controlling the fuel pressure to the spring-loaded fuel shutoff valve allows the valve to open, close, or partially open, depending on the applied fuel pressure.

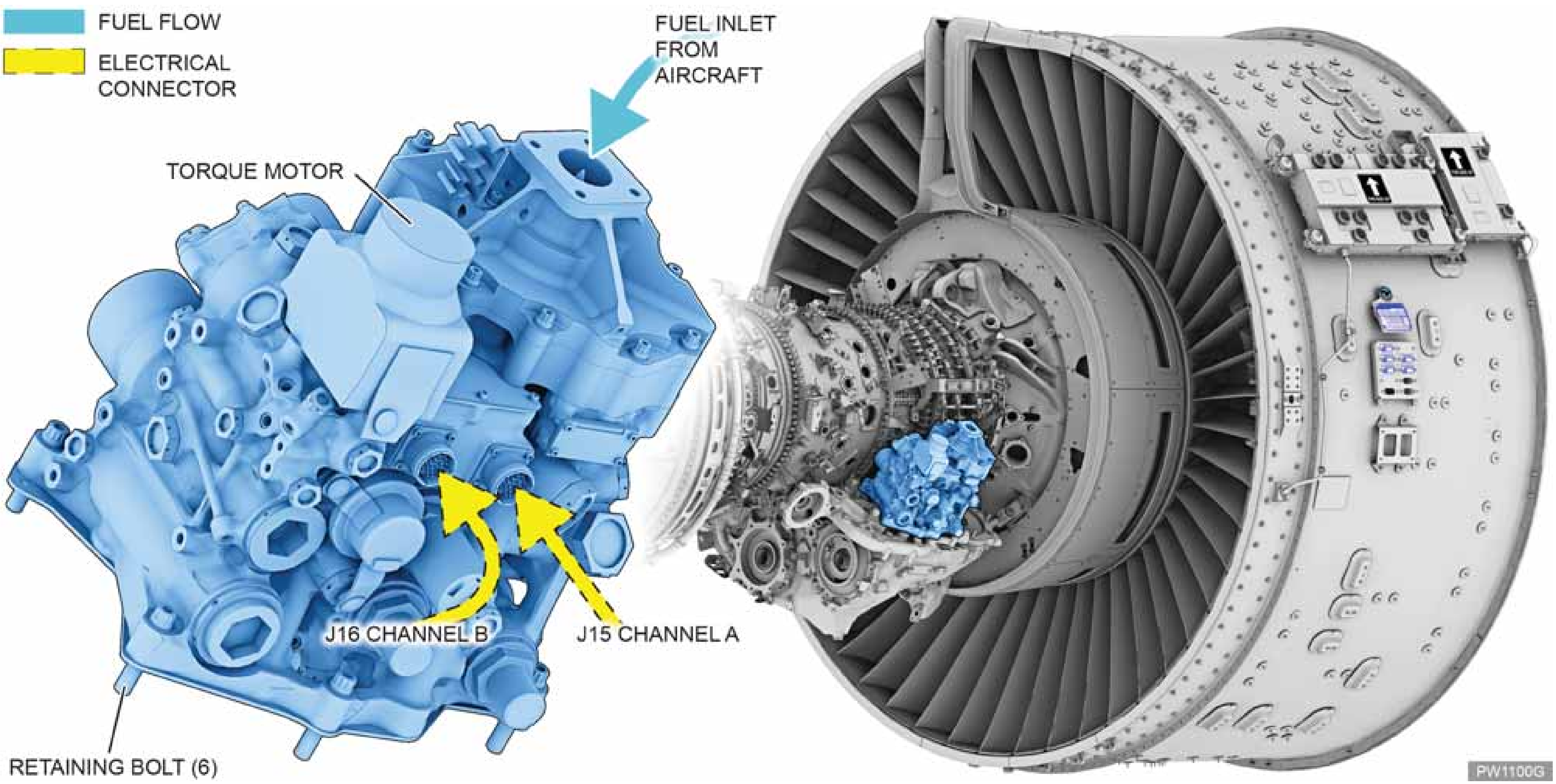
Response to Engine Operating Conditions

<u>Normal engine shutdown</u>: The torque motor reduces fuel pressure on the back side of the PRV to decrease fuel flow to the fuel metering valve and direct some fuel flow back to the fuel pump. At the same time, the torque motor increases fuel pressure to the fuel shutoff valve, closing it and stopping the flow of fuel to the engine.

<u>Engine overspeed event</u>: The torque motor reduces fuel pressure to the back side of the PRV to stop fuel flow to the fuel metering valve, while directing all fuel flow back to the fuel pump. At the same time, the torque motor increases the fuel pressure to the fuel shutoff valve, closing it rapidly.

<u>Thrust Control Malfunction (TCM) event</u>: The torque motor reduces fuel pressure to the back side of the PRV, limiting fuel flow to the fuel metering valve to a pre-set value, and returning the remaining fuel flow to the fuel pump. The torque motor also maintains enough fuel pressure to keep the shutoff valve partially open. Two proximity sensors, one for each channel, provide redundant shutoff valve feedback confirmation to the EEC.

In the event of TCM on the ground, the torque motor shuts down.



FUEL DISTRIBUTION SYSTEM – IFPC FUEL AND ELECTRIC FLOWS

FUEL DISTRIBUTION SYSTEM

Integrated Fuel Pump and Control (IFPC) Cont.)

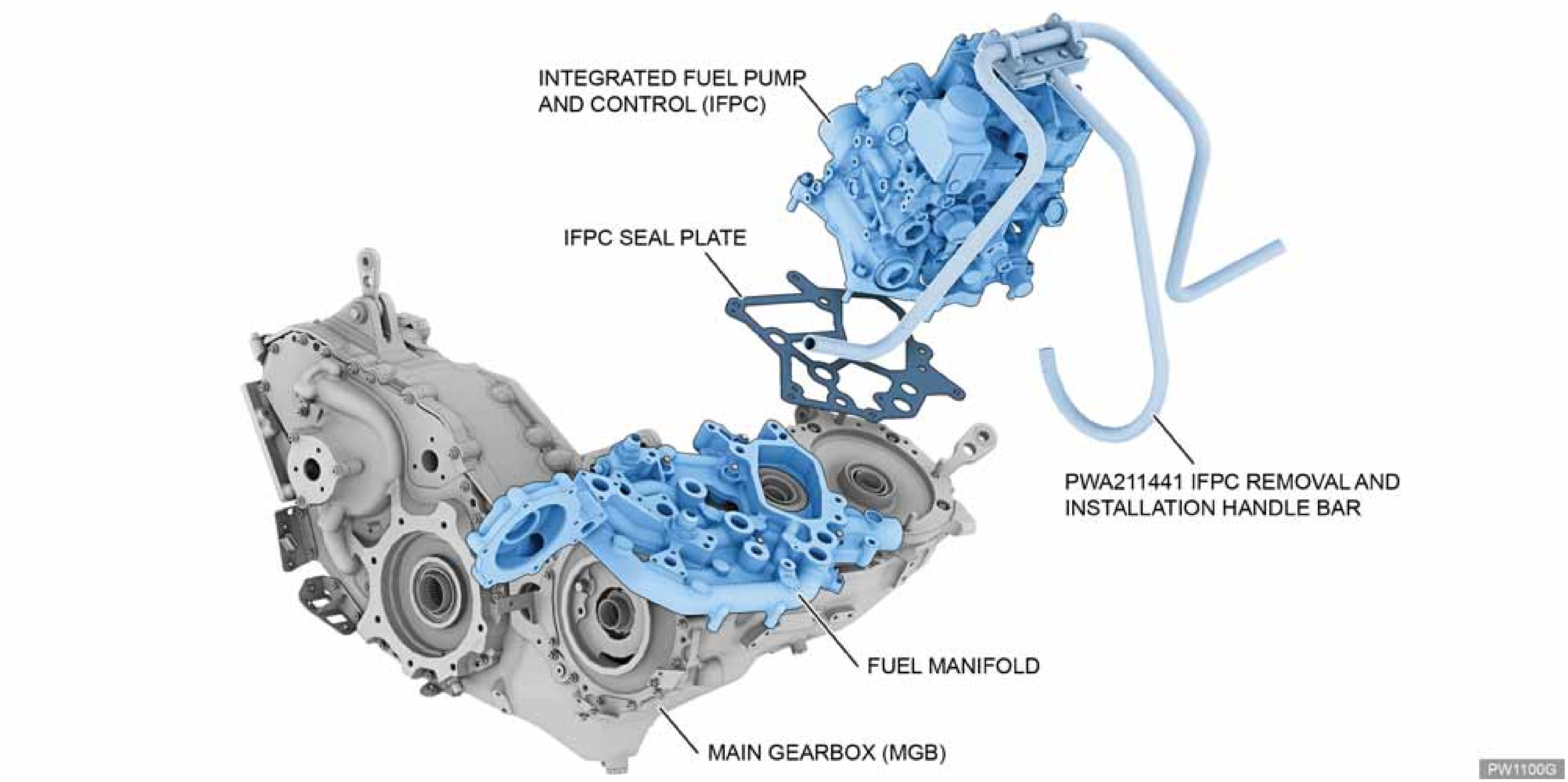
Removal

Special tool PWA211441 is required to remove and install the IFPC.

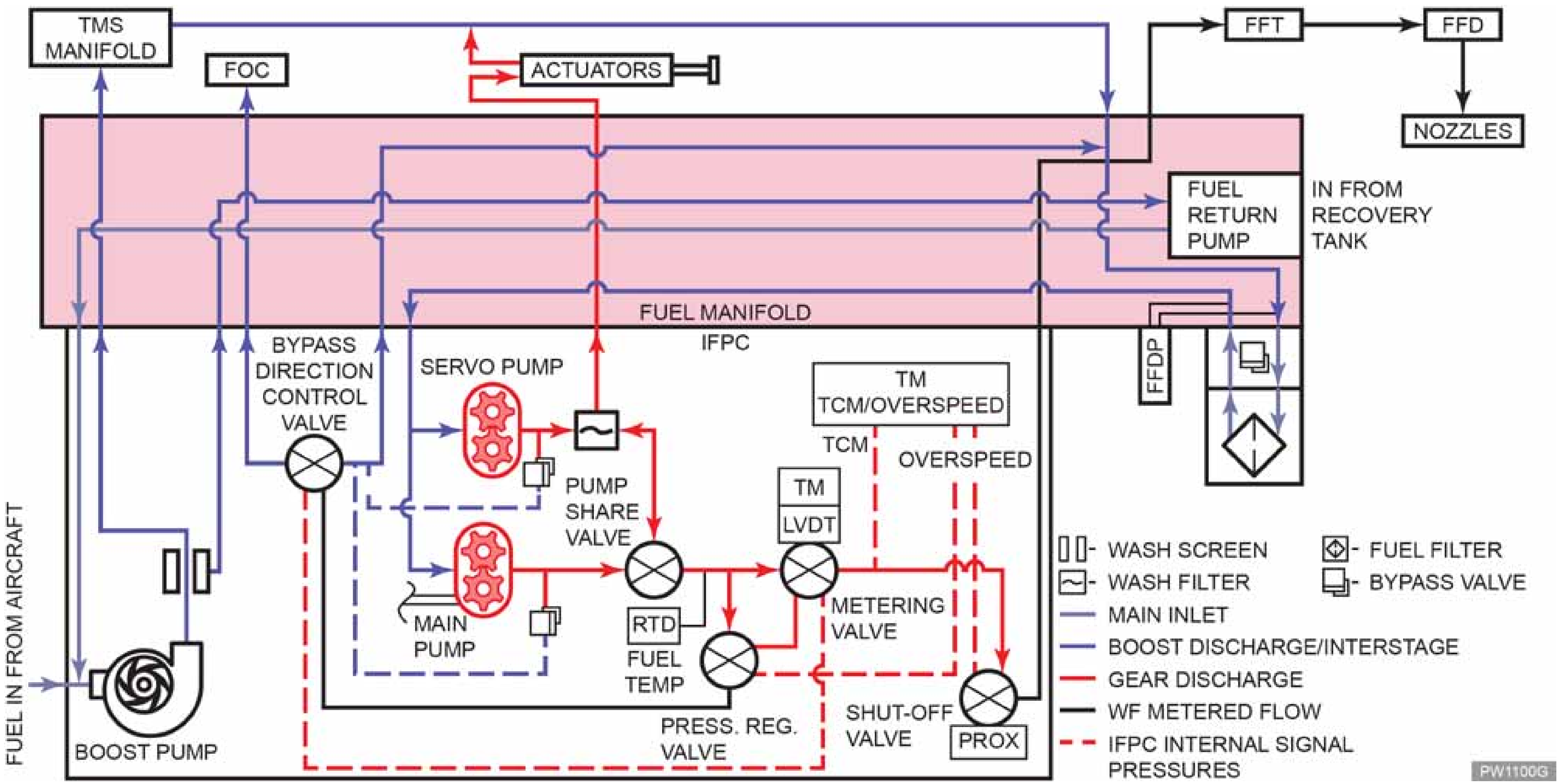
Safety Conditions

CAUTION

HOLD THE WEIGHT OF THE IFPC DURING INSTALLATION. DO NOT LET THE IFPC HANG ON THE DOWEL PINS OR ON THE DRIVE SHAFT WITHOUT THE BOLTS ENGAGED. IF YOU DO, THE IFPC COULD DISENGAGE FROM THE MANIFOLD AND DROP. IFPC WEIGHT IS 63 LBS (29 KG). IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE IFPC.



FUEL DISTRIBUTION SYSTEM – IFPC SPECIAL TOOLING



FUEL DISTRIBUTION SYSTEM – IFPC OPERATION

FUEL INDICATING SYSTEM (Cont.)

Fuel Temperature Sensors (Tfuel)

Purpose:

The sensors provide fuel temperature to the EEC. The Tfuel signal is used for fuel scheduling, fuel flow calculation and control scheduling of the Fuel Oil Cooler Bypass Valve.

Location:

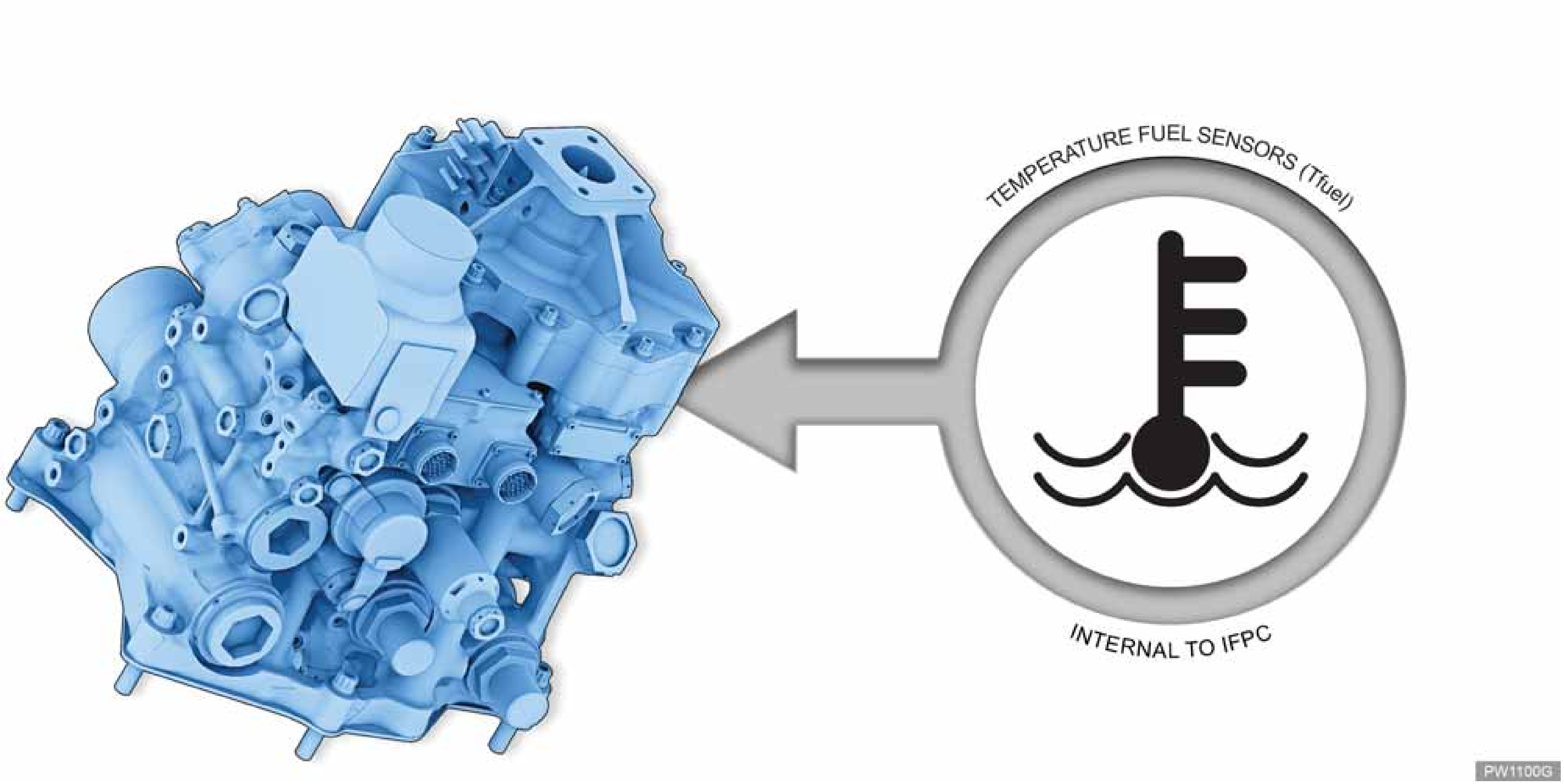
The sensors are built into the IFPC mounted on the Main Gearbox at 4:00.

Description:

The sensors are dual channel Resistive Temperature Detector (RTD), each with an independent sensing element per channel. The sensor is integral to the IFPC.

Operation:

The sensors monitor fuel temperatures prior to metering, and provide feedback to the EEC for positioning the FOHE oil bypass valve.



FUEL DISTRIBUTION SYSTEM – IFPC FUEL TEMPERATURE SENSORS

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Manifold

Purpose:

PMT

The fuel manifold supplies mounting and sealing of the IFPC, the fuel return pump, the Fuel Filter Differential Pressure (FFDP) sensor and the fuel filter housing assembly. It also transfers fuel between the components and serves as the connection point for external fuel lines.

Location:

The fuel manifold is located on the right side of the engine and is attached to the Main Gearbox.

Description:

The aluminum manifold is attached to the MGB with five nuts.

Operation:

Fuel transfer through the manifold is conducted through internal passages, reducing the need for external fuel tubes.

Fuel Manifold Drain Plug

Purpose:

LRU PMT

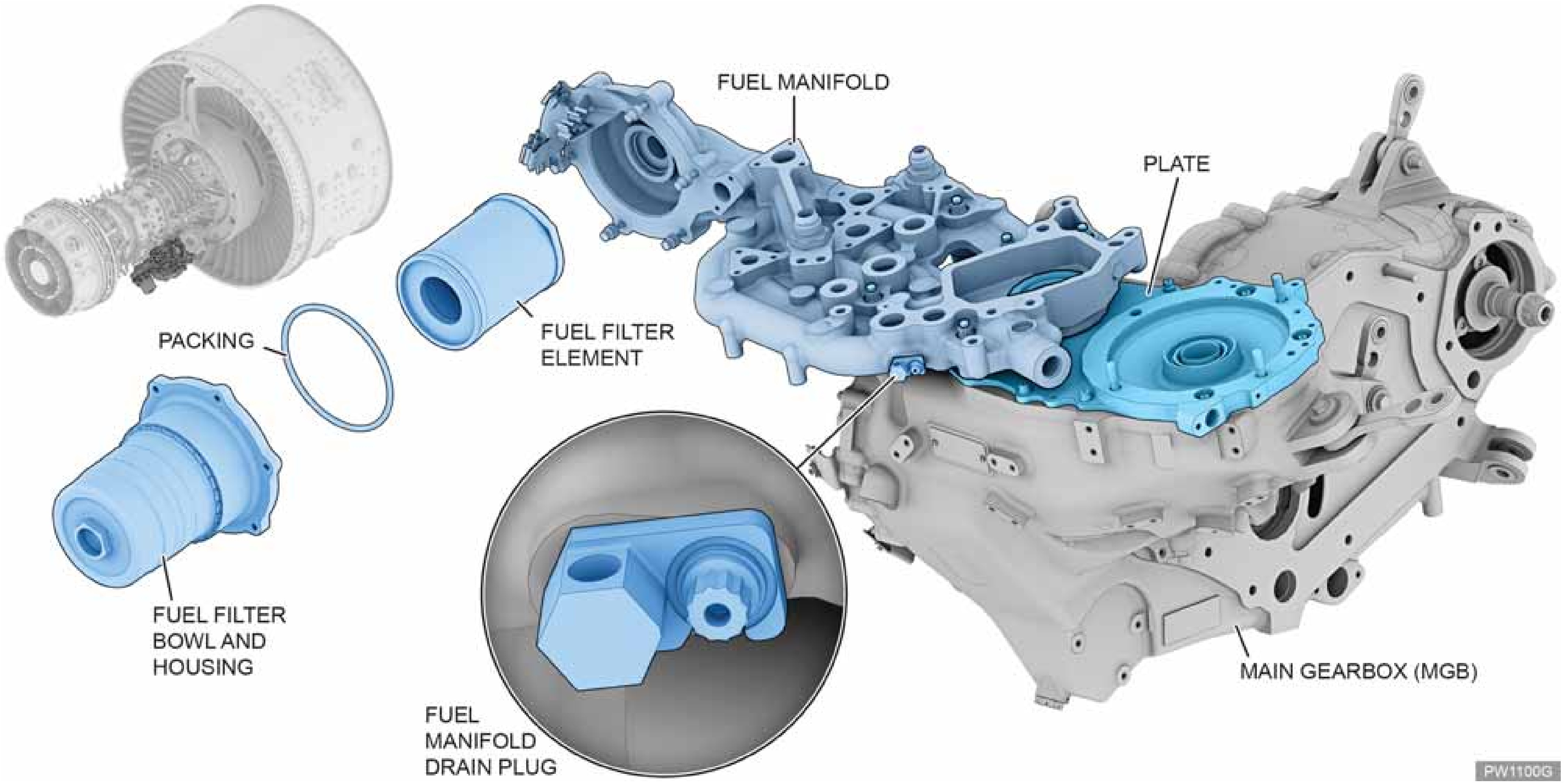
The fuel manifold drain plug is removed to drain fuel from the fuel manifold to facilitate maintenance of the Fuel System.

Location:

The fuel manifold drain plug is located on the right side of the fuel manifold.

Description:

The fuel manifold drain plug is machined from aluminum and is installed at the bottom passage of the manifold to drain residual fuel while performing maintenance on certain Fuel System components.



FUEL DISTRIBUTION SYSTEM – FUEL MANIFOLD ATTACHMENT TO MAIN GEARBOX

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Filter Assembly

Purpose: LRU PMT

The fuel filter assembly removes solid contaminants from the pressurized fuel sent from the IFPC.

Location:

The assembly is attached to the fuel manifold at 3:00 on the right side of the engine.

Description:

The fuel filter assembly consists of these components:

- housing and adapter
- filter element
- maintenance shutoff valve
- bypass valve.

FUEL DISTRIBUTION SYSTEM

Fuel Filter Assembly (Cont.)

Fuel Filter Bowl and Housing

PMT

The fuel filter bowl and housing contain the fuel that flows through the fuel filter element. An O-ring provides sealing between the fuel filter bowl and the fuel filter housing. A second O-ring provides sealing between the fuel filter housing and the fuel manifold.

The fuel filter bowl is threaded hand-tight into the fuel filter housing. A ratchet lever is used to secure the fuel filter bowl after assembly.

Safety Conditions

WARNING

MAKE SURE THE FUEL SYSTEM IS SHUT OFF BEFORE REMOVING THE FUEL FILTER HOUSING. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

FUEL DISTRIBUTION SYSTEM

Fuel Filter Assembly (Cont.)

Fuel Filter Element

LRU PMT

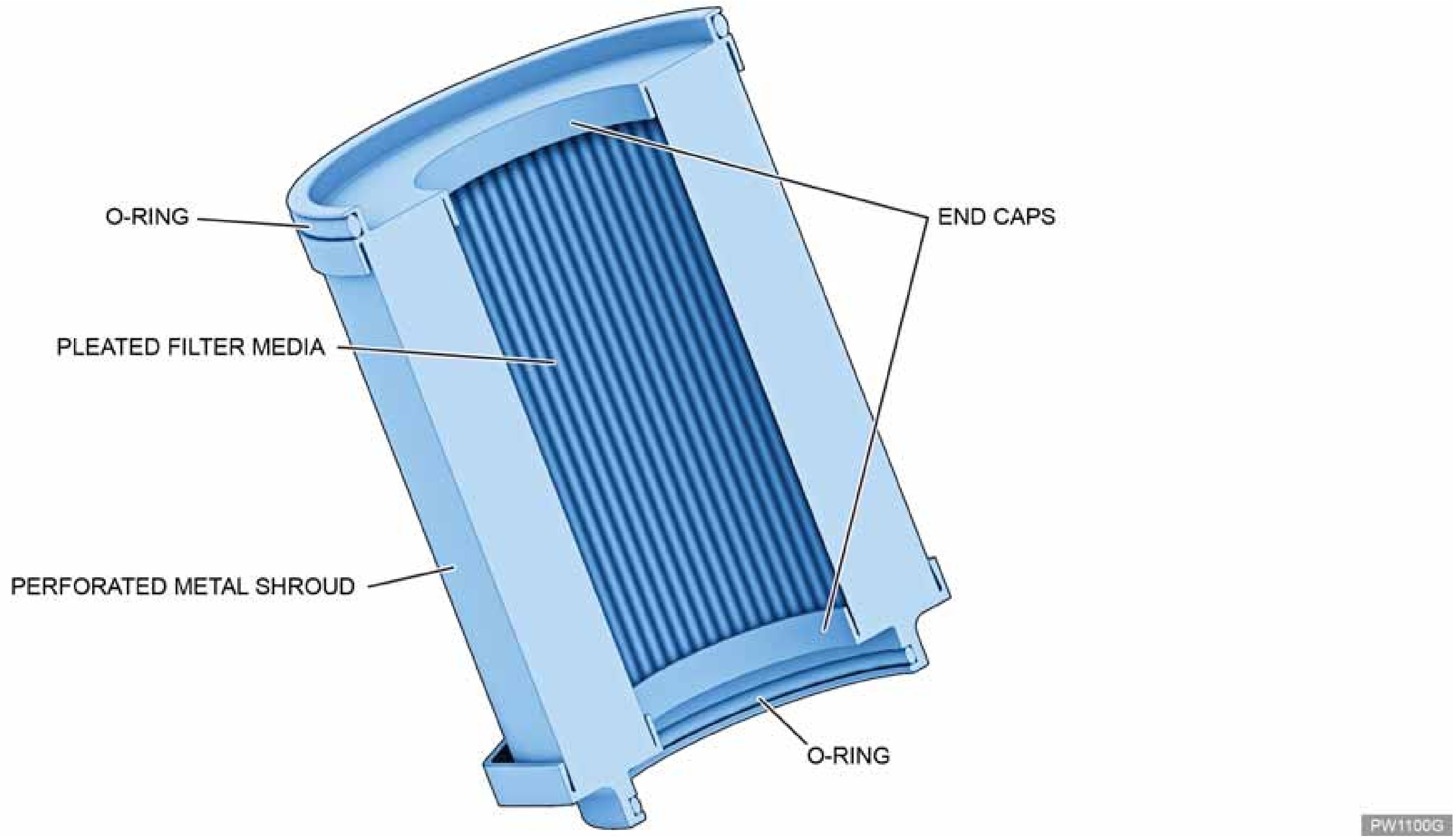
The fuel filter element is a 25-micron filter that removes solid contaminants from the pressurized fuel sent to the IFPC.

Fuel is delivered to the inside of the filter and then flows outward through the filter media. The filter is a disposable type constructed of multiple pleated paper media.

Safety Conditions

WARNING

MAKE SURE THE FUEL SYSTEM IS SHUT OFF BEFORE REMOVING THE FUEL FILTER ELEMENT. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.



FUEL DISTRIBUTION SYSTEM – FUEL FILTER ELEMENT

FUEL DISTRIBUTION SYSTEM

Fuel Filter Assembly (Cont.)

Fuel Filter Maintenance Shutoff Valve

The fuel filter maintenance shutoff valve is a spring-loaded mechanical valve installed in the adapter. During filter change, the valve closes the port for fuel flow, limiting drainage.

When the fuel filter is installed, it pushes the valve against the spring to open the port for fuel flow.

FUEL DISTRIBUTION SYSTEM

Fuel Filter Assembly (Cont.)

Fuel Filter Bypass Valve

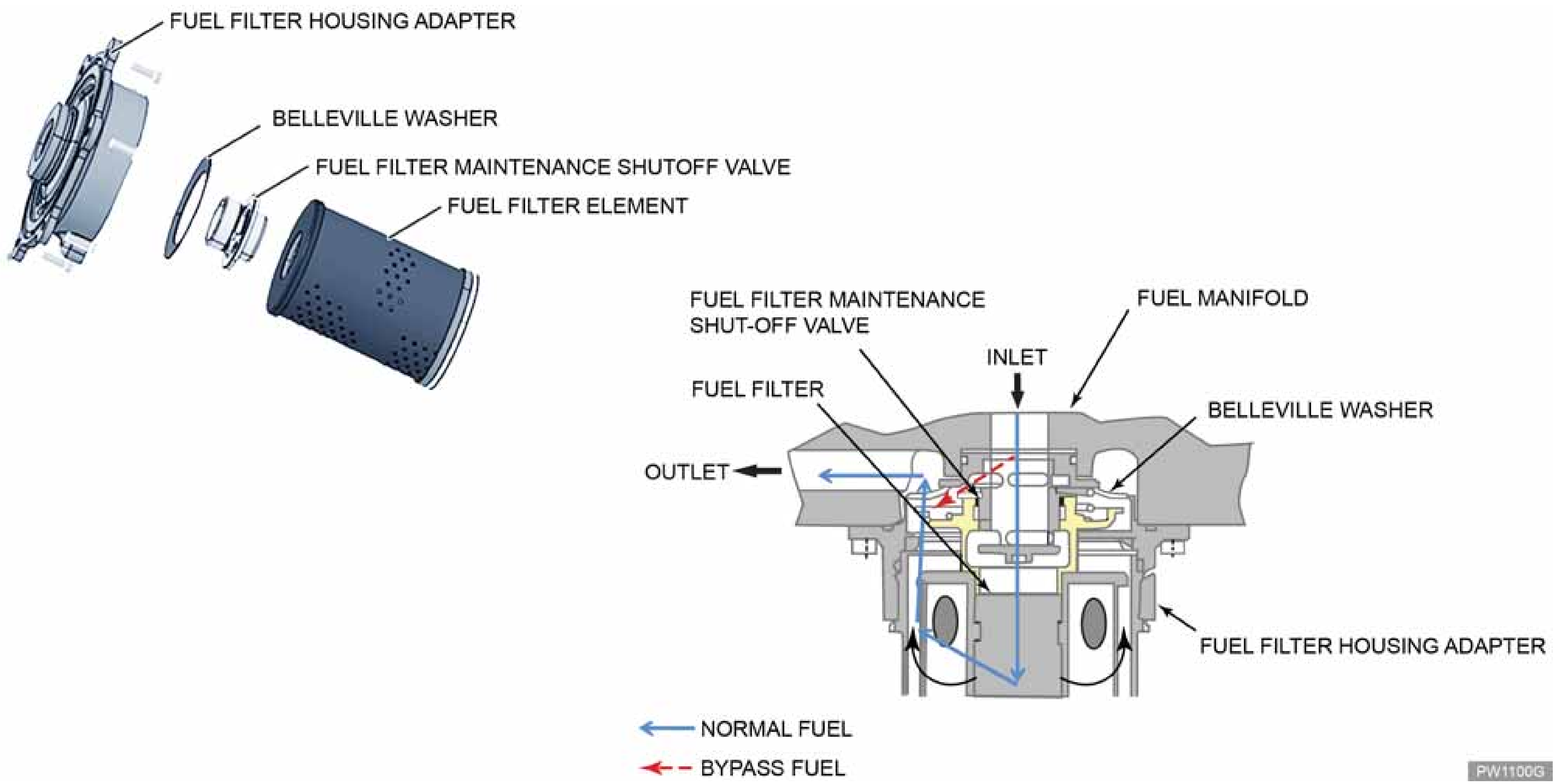
The fuel filter bypass valve allows fuel to bypass the filter element if it should become clogged.

The valve has a Belleville washer design and is installed between the adapter and the fuel filter maintenance shutoff valve.

During normal engine operation the bypass valve covers an internal passage between the adapter and the fuel manifold that is connected to the outlet port of the adapter.

When the fuel filter becomes clogged, sufficient fuel pressure is built up to push the valve open, allowing unfiltered fuel to port directly to the outlet port of the adapter.

Pressure upstream and downstream of the fuel filter is measured by the Fuel Filter Differential Pressure (FFDP) sensor and sent to the EEC. The EEC will send a “Fuel filter degraded” or “Fuel filter clogged” message to the Engine Interface Unit (EIU) at specific differential pressure values.



FUEL DISTRIBUTION SYSTEM – FUEL FILTER BYPASS VALVE

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Flow Divider (FFD)

LRU PMT

Purpose:

The Fuel Flow Divider is an EEC-controlled valve that directs metered fuel flow to the primary fuel nozzles during startup, and more evenly divides metered fuel flow between primary and secondary fuel nozzles above ground idle.

Location:

The FFD is mounted to a bracket at 6:00 just aft of the diffuser case.

Description:

The FFD consists of a dual-channel solenoid that is controlled by the EEC, and a spring and piston within the FFD housing. Fuel entering the FFD passes through a wire mesh inlet screen that captures any large debris present in the fuel.

A two-piece metal shroud covers the FFD solenoid. Cool bypass air is directed to the cavity between the FFD solenoid and the two-piece metal shroud to prevent overheating due to its proximity to the diffuser case.

Operation:

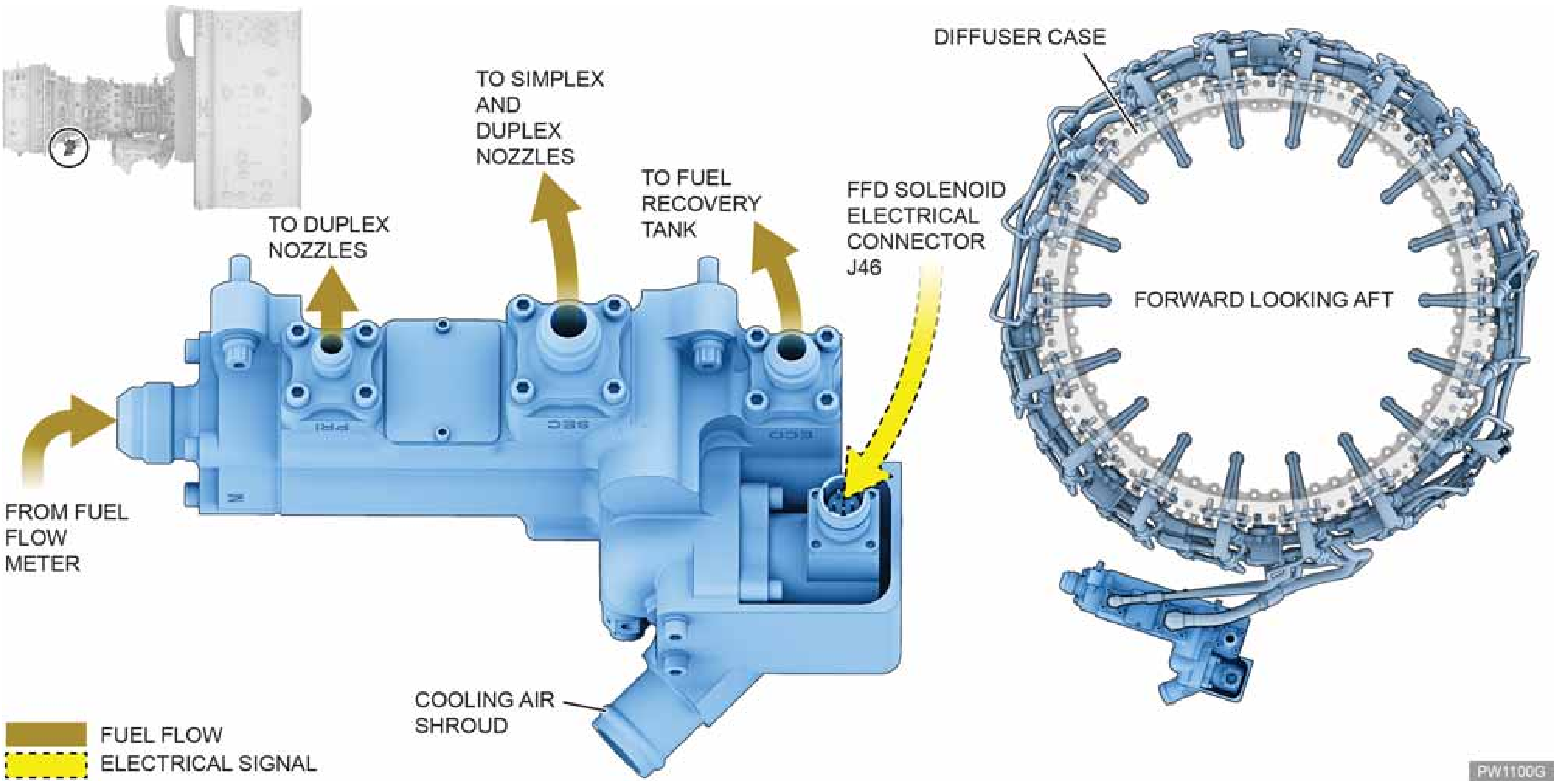
The FFD solenoid controls a high- and low-pressure drop capability from simplex to duplex fuel nozzles.

1. During engine start, the FFD is in the high differential pressure mode with the solenoid de-energized. This creates a high pressure drop across the secondary fuel circuit, allowing more primary fuel to flow for ignition and combustor acoustic mitigation at sub-cruise power.

2. Inlet fuel pressure forces the piston to move against the spring, opening the FFD. At higher power settings the FFD is in the low differential pressure mode with the solenoid energized. This closes off the primary circuit to the backside of the piston to create a low pressure drop across the secondary fuel circuit.

3. The change in pressure between primary and secondary circuits allows the spring to move the piston to an intermediate position, providing even fuel flow to both the primary and secondary fuel nozzles. The low differential pressure mode is used to reduce combustor pattern factor at and above cruise.

4. At shutdown, fuel pressure reduces and the spring moves the piston closed. The FFD shuts off the inlet, preventing fuel in the IFPC-to-FFD line from entering the combustor. The shutoff action also provides a drain path for remaining fuel in both lines to enter the fuel recovery tank (Eco tank).



FUEL DISTRIBUTION SYSTEM – FUEL FLOW DIVIDER (FFD)

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Nozzle Supply Manifolds

Purpose:

PMT

Fuel nozzle supply manifolds send fuel from the fuel manifold to the fuel nozzles.

Location:

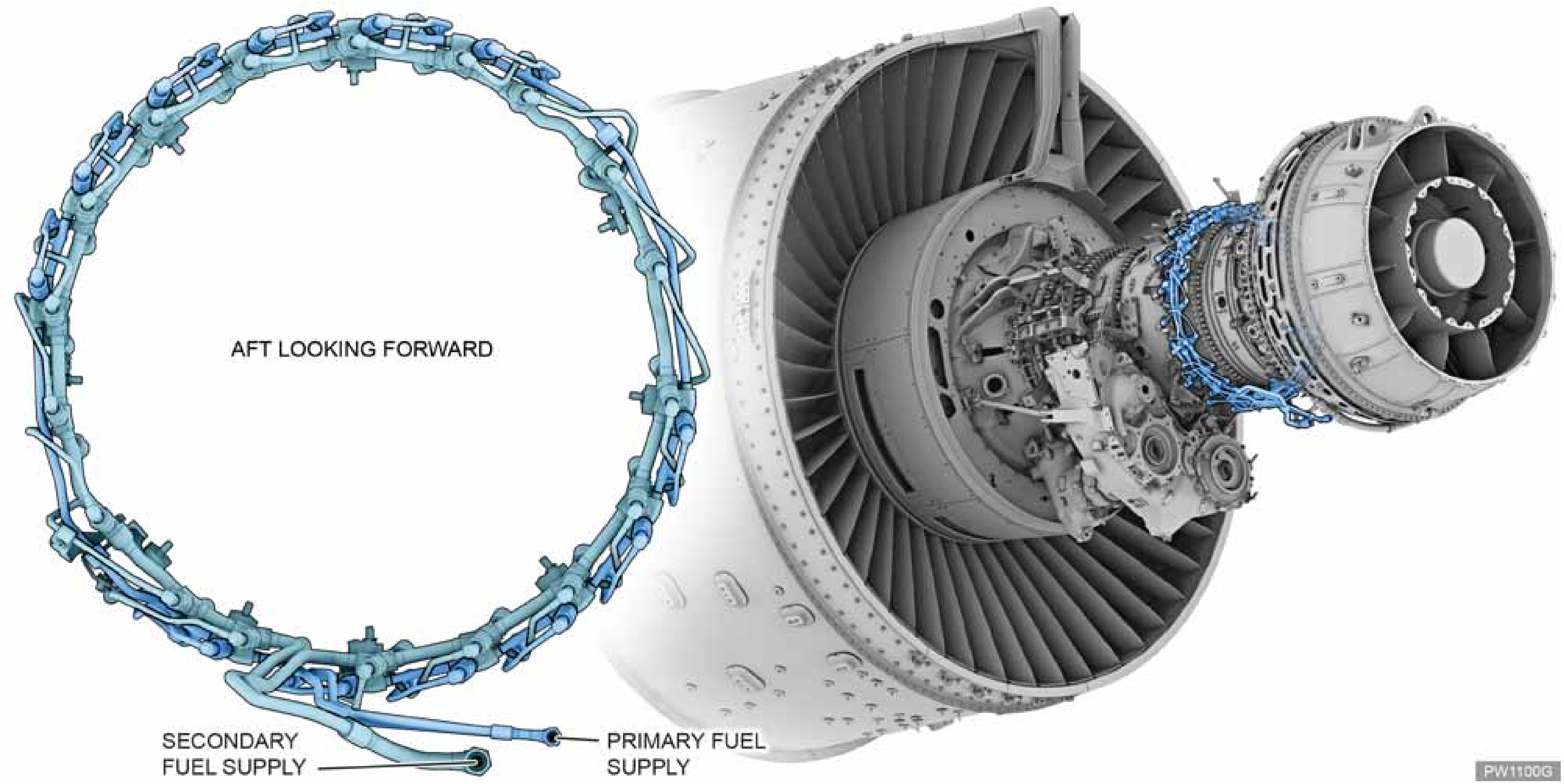
The supply manifolds are attached around the diffuser case.

Description:

One supply manifold provides primary fuel supply and the other provides secondary supply.

Operation:

The supply manifolds send fuel from the IFPC fuel divider ports to the fuel nozzles.



FUEL DISTRIBUTION SYSTEM – FUEL NOZZLE SUPPLY MANIFOLDS

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Nozzles

Purpose:

PMT

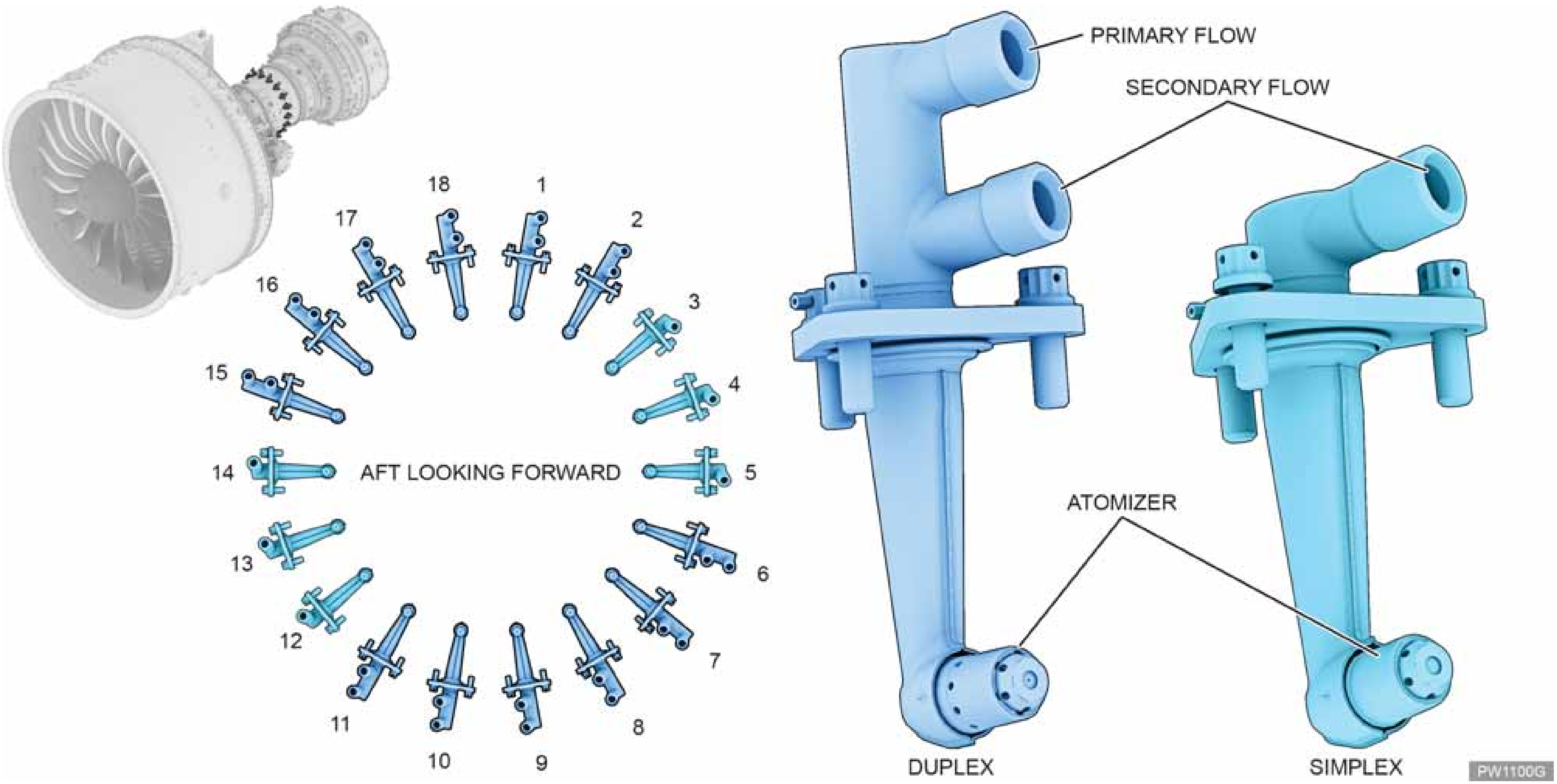
Eighteen fuel nozzles atomize fuel for combustion inside the combustor.

Location:

Fuel nozzles are mounted to the outer diffuser case.

Description:

Twelve of the eighteen nozzles are duplex nozzles with both a primary and secondary fuel flow path. The remaining six are simplex nozzles that provide only a secondary fuel path.



FUEL DISTRIBUTION SYSTEM – FUEL NOZZLES (1 OF 2)

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Nozzles (Cont.)

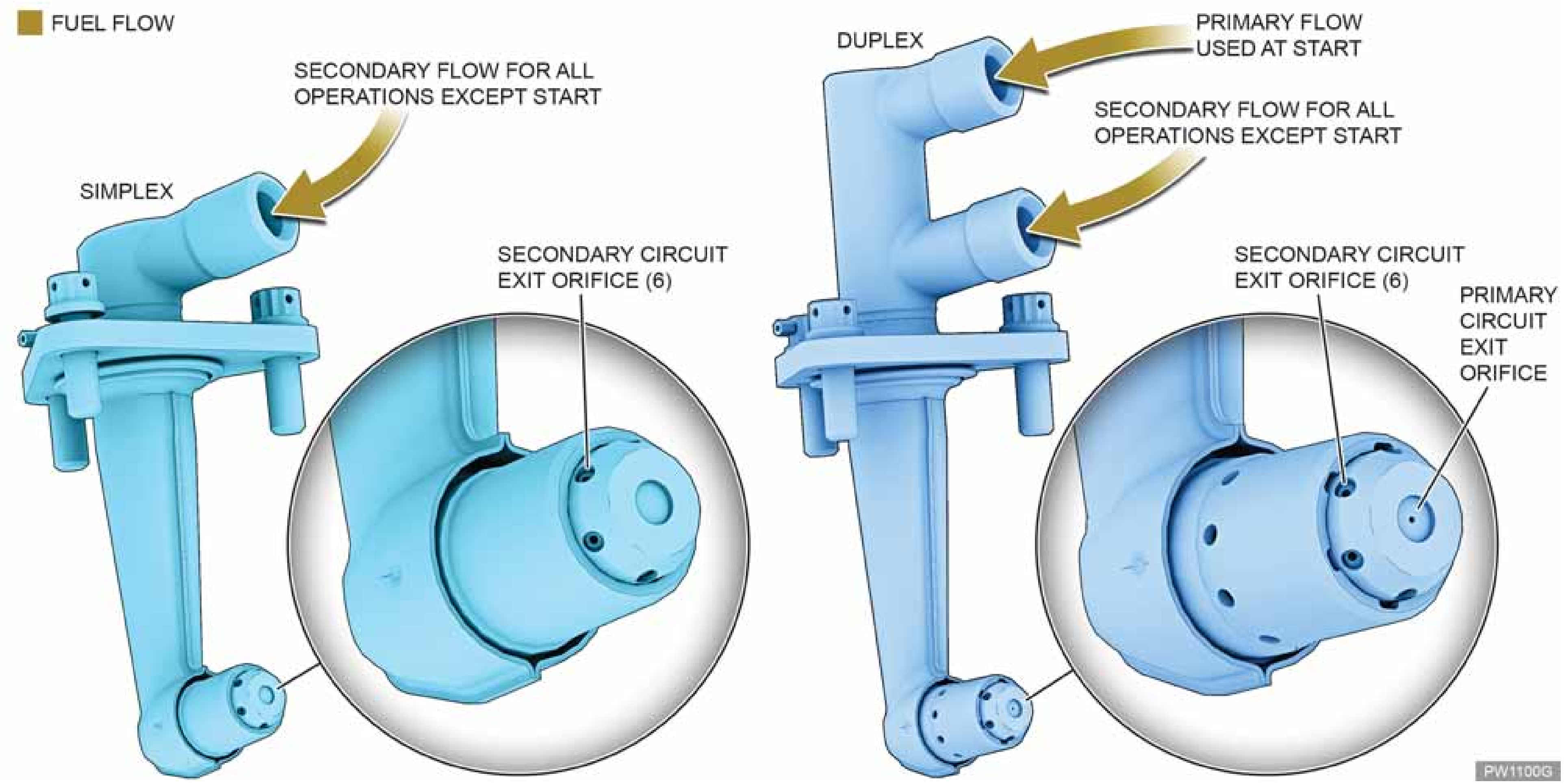
Operation:

Only primary fuel flow is used during initial start. Both primary and secondary fuel flows are used to achieve all other power settings.

At one end of each duplex fuel nozzle is an atomizer installed in the combustion chamber that features a single, primary orifice and six radial jet secondary orifices, which use combustor inlet air to atomize the fuel.

Simplex fuel nozzles have only the six radial jet secondary orifices.

All fuel nozzles have their own support housing and no individual metering or check valves.



FUEL DISTRIBUTION SYSTEM – FUEL NOZZLES (2 OF 2)

FUEL DISTRIBUTION SYSTEM (Cont.)

Main Fuel Supply Hose

Purpose: LRU PMT

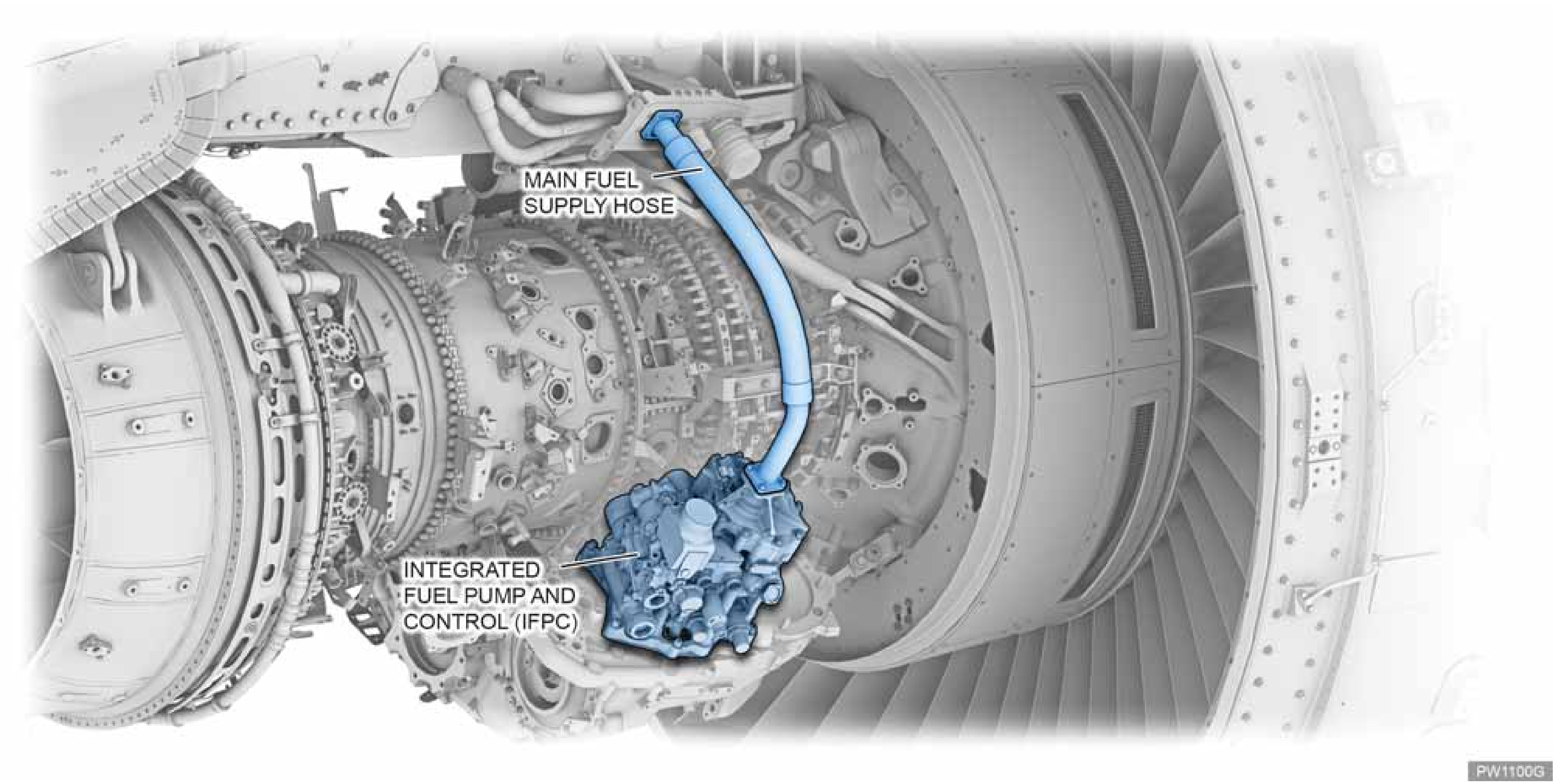
The main fuel supply hose is a conduit between the pylon connection and the inlet of the IFPC.

Location:

The hose is on the left side of the engine just aft of the CIC.

Description:

The hose is a braided flexhose to handle relative motion between the engine and the pylon, with a fire sleeve on the outside for protection.



FUEL DISTRIBUTION SYSTEM – MAIN FUEL SUPPLY HOSE CONNECTION

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Recovery Tank

Purpose: LRU PMT

The fuel recovery tank collects the fuel from the primary and secondary fuel lines that have drained from the Fuel Flow Divider (FFD) after engine shutdown.

Location:

The fuel recovery tank is located on the LPC case at 6:00.

Description:

Combustor pressure and gravity provide the motive force to push the fuel from the primary and secondary fuel lines into the tank.

Operation:

The outlet port of the fuel recovery tank has a one-way check valve (internal to the tank) that is spring-loaded closed. The check valve is covered by an outlet float valve. The two valves work together to drain fuel from the tank.

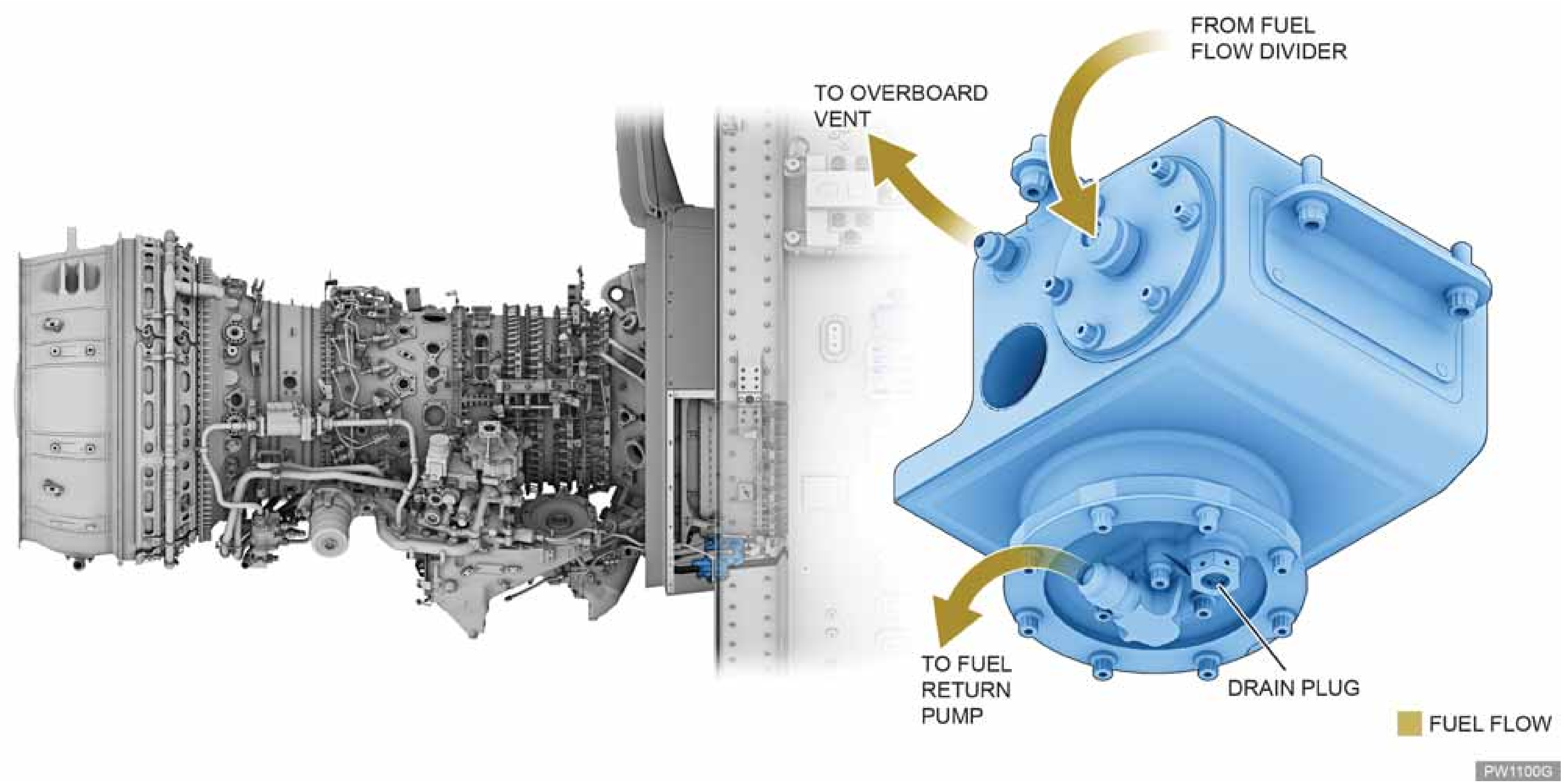
1. During engine start the boost pump in the IFPC directs pressurized fuel to the fuel return pump.

2. The fuel return pump opens the check valve and draws the fuel from the fuel recovery tank back into the boost pump fuel flow.

3. As fuel level decreases inside the fuel recovery tank, the outlet float drops until it reaches the bottom, sealing the tank outlet. The check valve remains open as long as the engine is running.

4. At shutdown the check valve closes and the outlet float valve rises with the fuel level in the tank.

5. During engine start, the IFPC flows fuel through the fuel return pump. This creates a siphon effect that draws fuel from the fuel recovery tank to be used for engine operation.



FUEL DISTRIBUTION SYSTEM – FUEL RECOVERY TANK

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Return Pump

Purpose: LRU PMT

The fuel return pump draws the fuel from the fuel recovery tank back to the boost pump at engine startup.

Location:

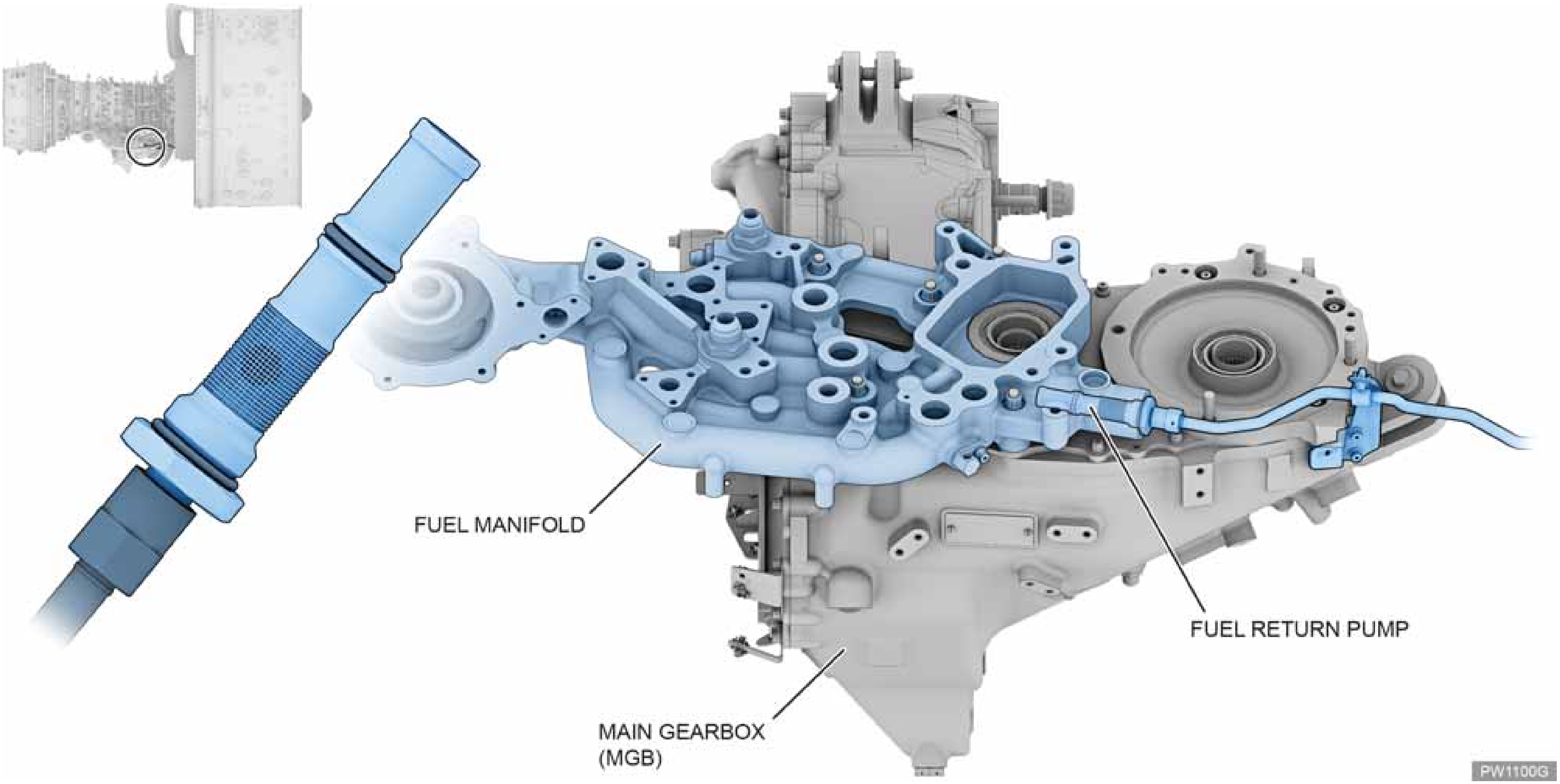
The pump is mounted on the fuel manifold, which is attached to the Main Gearbox on the right side of the engine at 4:00.

Description:

The fuel return pump receives pressurized fuel from the boost pump during engine operation.

Operation:

Pressurized fuel flows through the pump, creating the motive flow in a Venturi effect to draw the fuel from the fuel recovery tank. The combined fuel is returned to the inlet of the boost pump.



FUEL DISTRIBUTION SYSTEM – FUEL RETURN PUMP

FUEL DISTRIBUTION SYSTEM (Cont.)

Return-to-Tank (RTT) Valve

Purpose: LRU PMT

The Return-to-Tank (RTT) valve controls fuel flow back to the fuel tank from downstream of the Integrated Drive Generator Fuel/Oil Heat Exchanger (IDG FOHE), and before it enters the engine Fuel/Oil Heat Exchanger as part of the Thermal Management System (TMS).

Location:

The valve is attached to the TMS manifold at 9:00.

Description:

The RTT valve is an assembly consisting of a dual-channel solenoid valve, two fuel temperature sensors that are Resistance Temperature Detectors (RTDs), and two proximity sensors, all contained within a housing. The housing has one electrical connector, a fuel inlet port and a fuel outlet port.

The RTT valve is controlled by the EEC and is actuated based on aircraft altitude, ambient temperature, fuel temperature, and fuel flow.

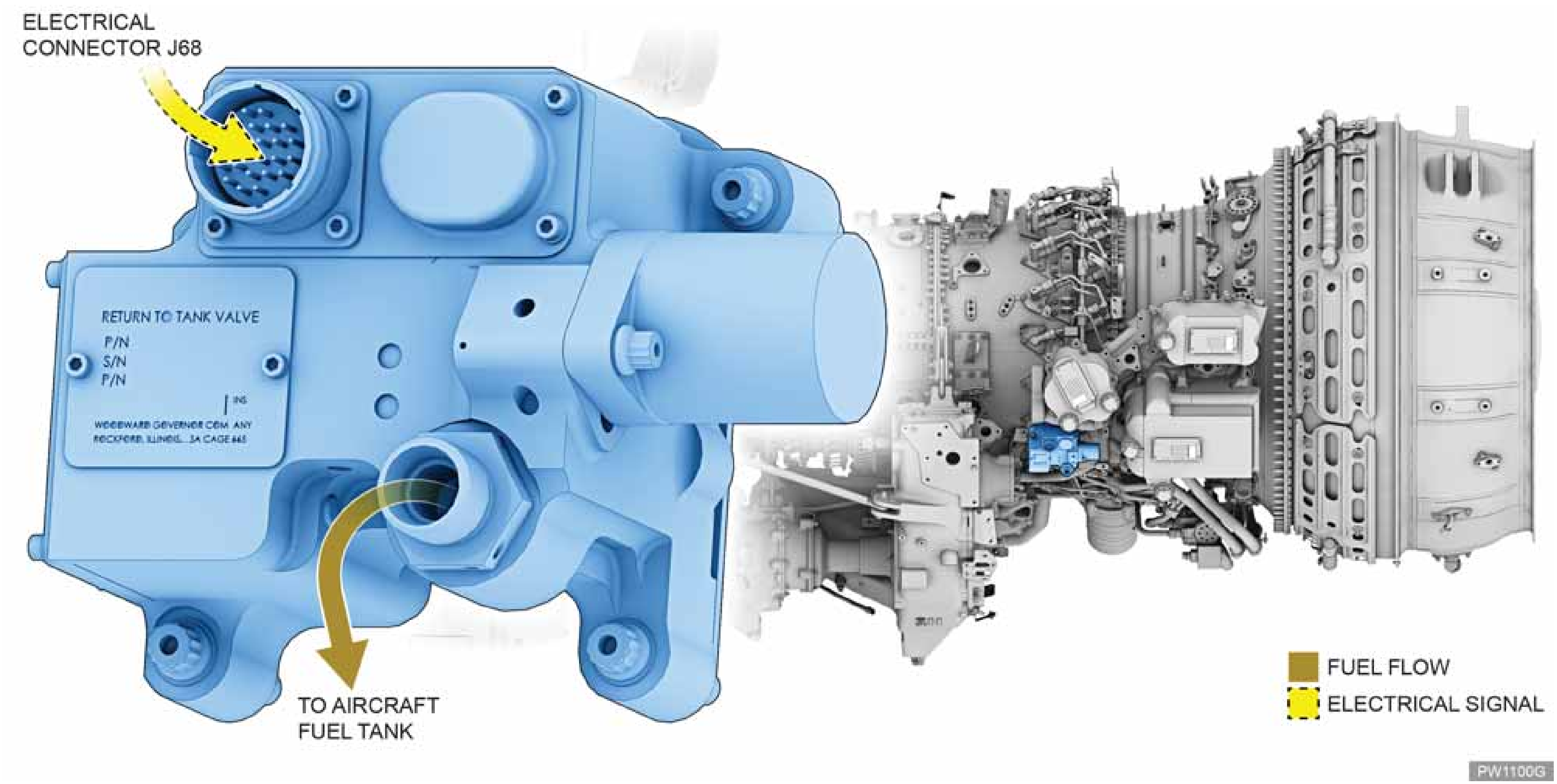
Operation:

The RTT sends the fuel temperature signal to the EEC. At a specific fuel temperature, the EEC will energize the solenoid valve to open, directing some fuel back to the fuel tank.

Proximity sensors monitor the solenoid valve position and send an “open” signal as position feedback to the EEC. When the fuel temperature has decreased to a specific temperature, the EEC will de-energize the solenoid, directing the fuel back to the engine Fuel System.

When the RTT valve is open it helps to cool IDG oil by increasing fuel flow through the IDG FOHE, removing additional heat.

This heated fuel is then directed back to the fuel tank, where the heat dissipates. This effect helps to maintain a lower overall fuel temperature, which in turn keeps the engine oil temperature lower when the fuel passes through the FOHE.



FUEL DISTRIBUTION SYSTEM – RETURN-TO-TANK (RTT) VALVE

FUEL DISTRIBUTION SYSTEM (Cont.)

Fuel Circulation

The fuel flow process for external components is shown below.

1. Fuel from the aircraft flows through the main supply line to the engine fuel pump boost inlet port of the Integrated Fuel Pump and Control (IFPC).

2. The boost stage pumps fuel at low pressure through the IDG and Engine Fuel/Oil heat exchangers, where fuel is heated and de-iced. The Return-to-Tank (RTT) valve sends a portion of fuel back to the aircraft tank from downstream of the IDG Fuel/Oil Heat Exchanger, but before it enters the engine Fuel/Oil Heat Exchanger as part of the Thermal Management System.

3. The heated fuel passes through the fuel filter, which is installed in a housing attached to the fuel manifold.

4. Fuel flows to the gear stage inlet port of the fuel pump. The pump sends high-pressure fuel through a fuel metering valve in the IFPC.

5. The EEC commands the metering valve in the IFPC to a position that will supply the correct amount of fuel for engine operation.

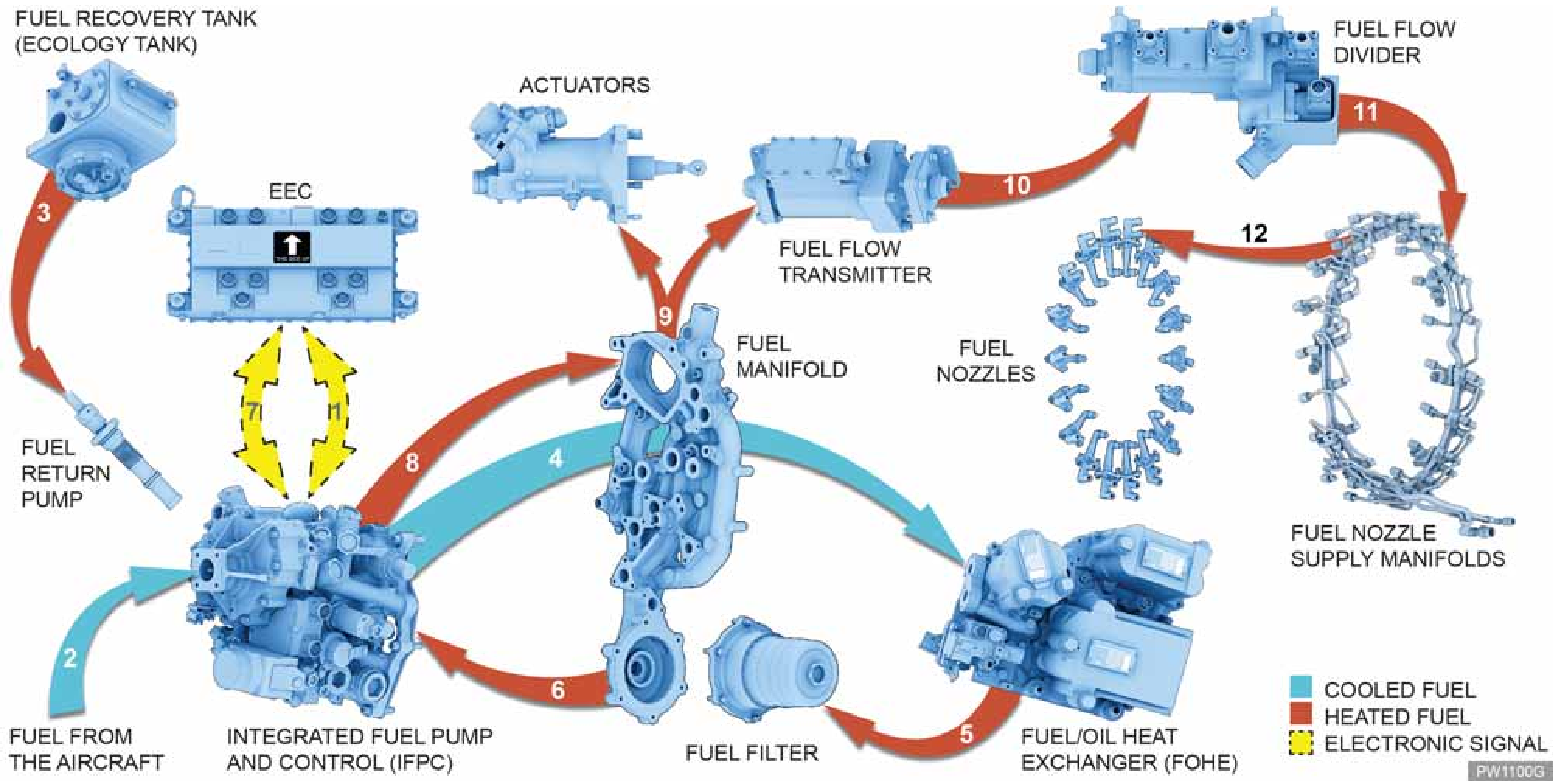
6. Metered fuel travels from the IFPC to the fuel manifold.

7. Fuel from the manifold is sent to the engine system actuators and the fuel flow transmitter.

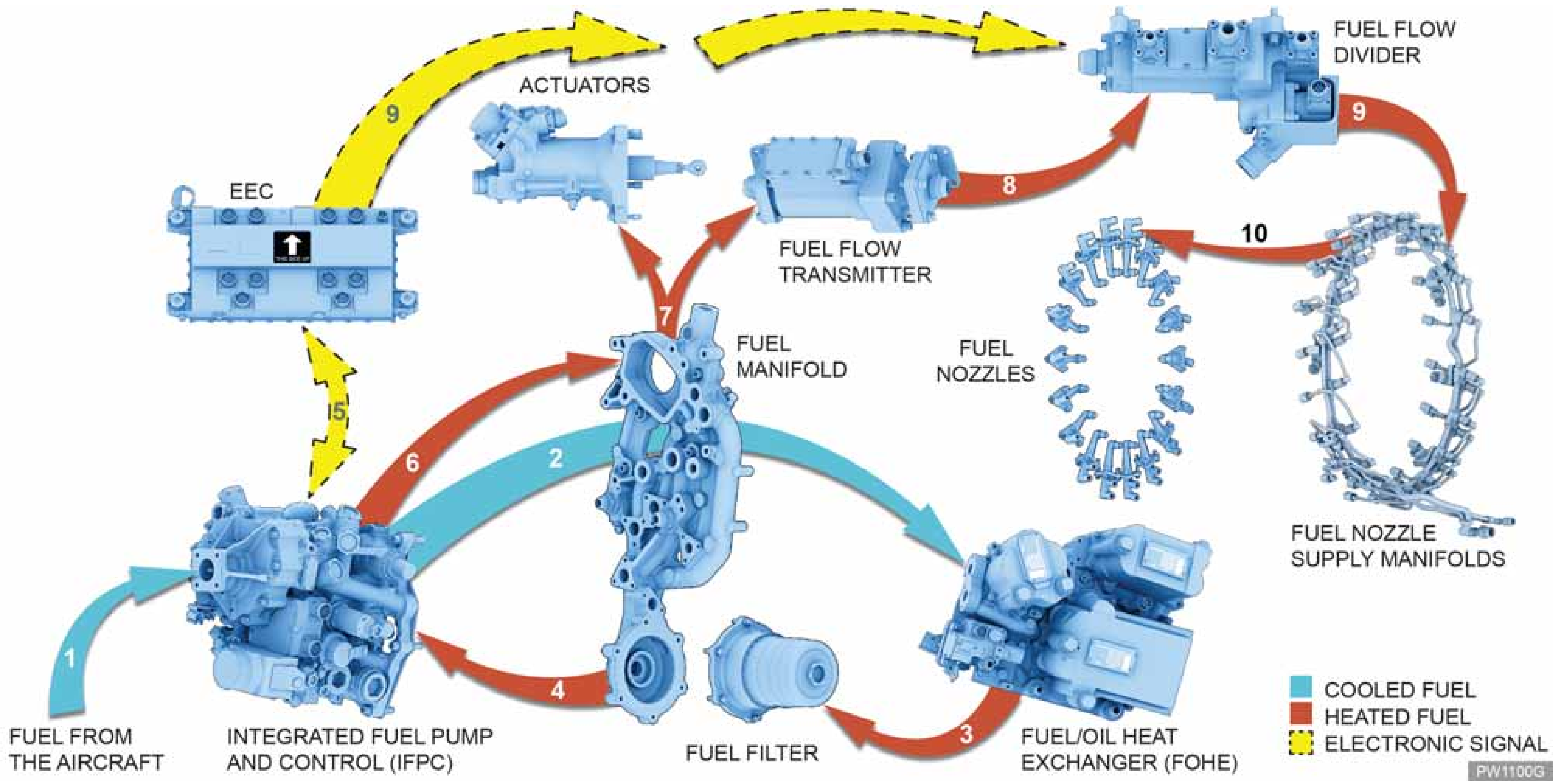
8. The fuel flow transmitter sends a fuel flow rate signal to the EEC and then sends the fuel to the Fuel Flow Divider.

9. The EEC commands the Fuel Flow Divider to send fuel to the fuel nozzle supply manifolds.

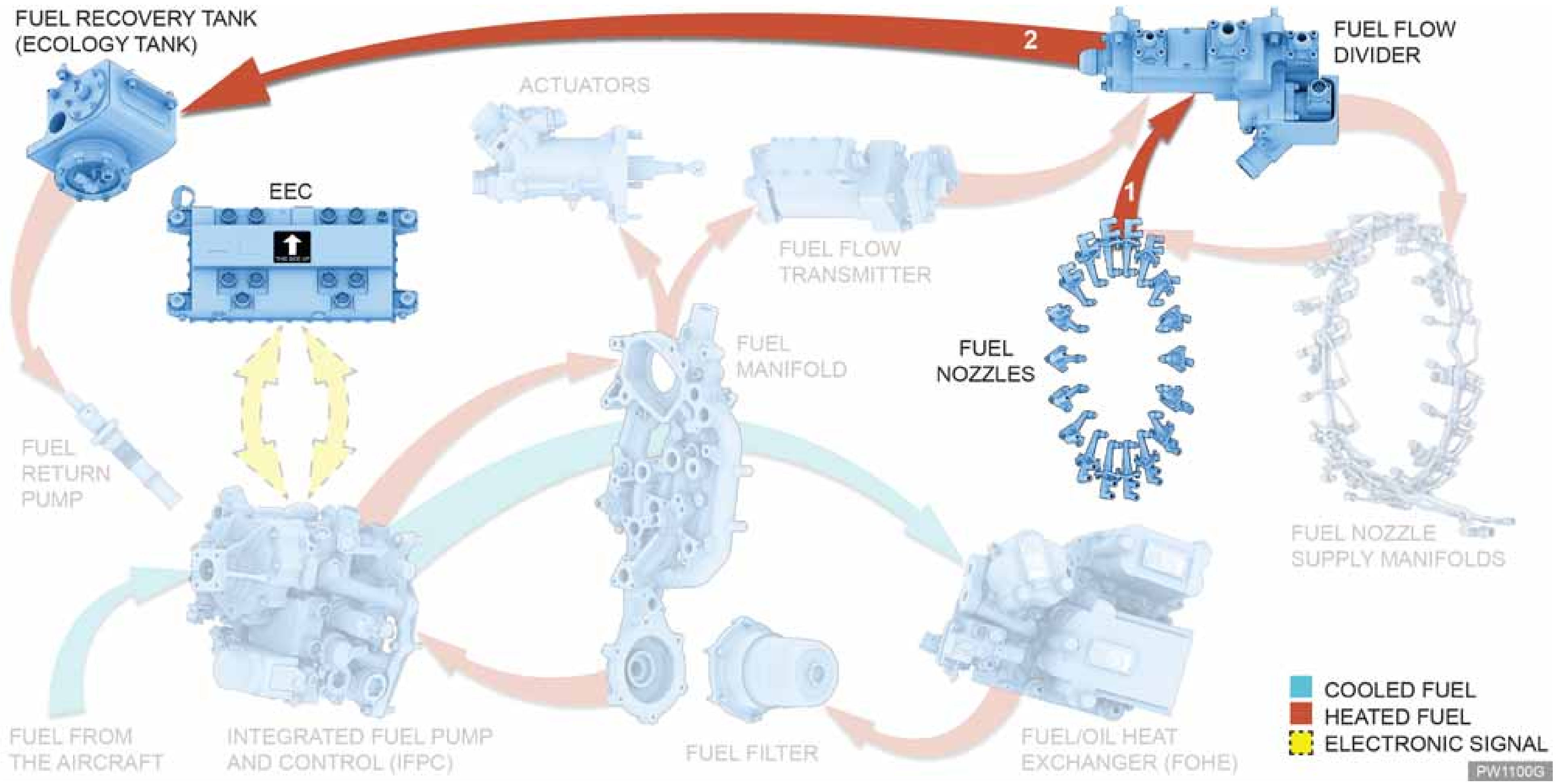
10. The fuel supply manifolds deliver fuel to the fuel nozzles.



FUEL FLOW DURING ENGINE STARTUP



FUEL FLOW DURING ENGINE OPERATION



FUEL FLOW DURING ENGINE SHUTDOWN

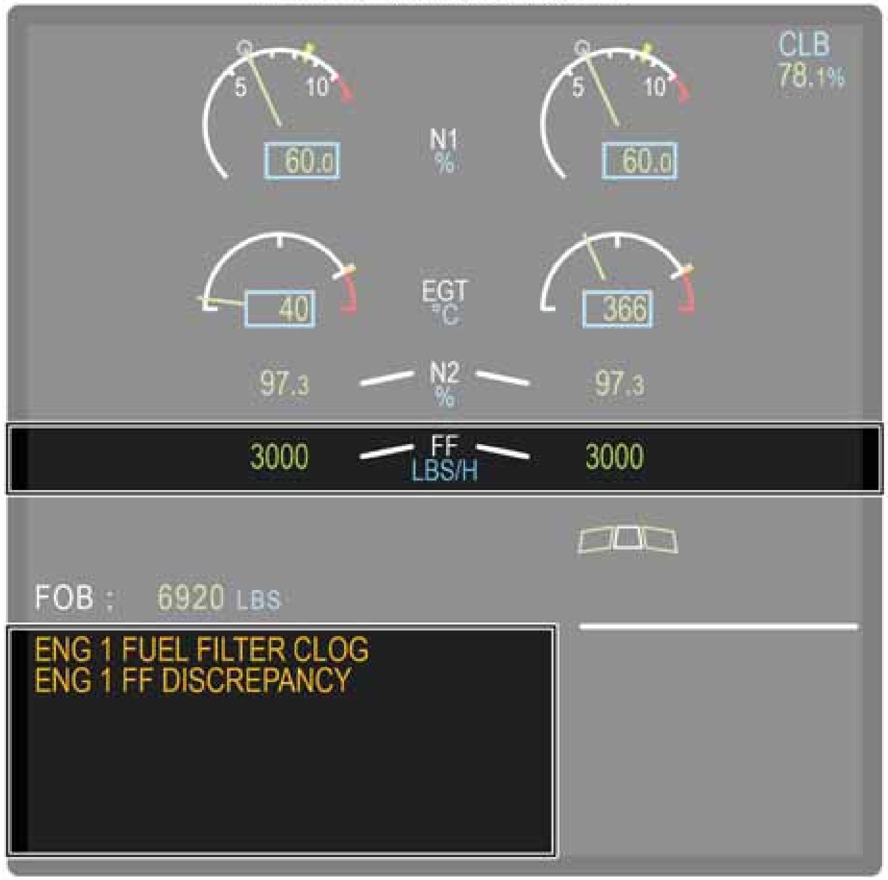
FUEL INDICATING SYSTEM

The Fuel Indicating System monitors fuel flow and sends messages to the flight deck display about the system status and possible fuel filter clogs.

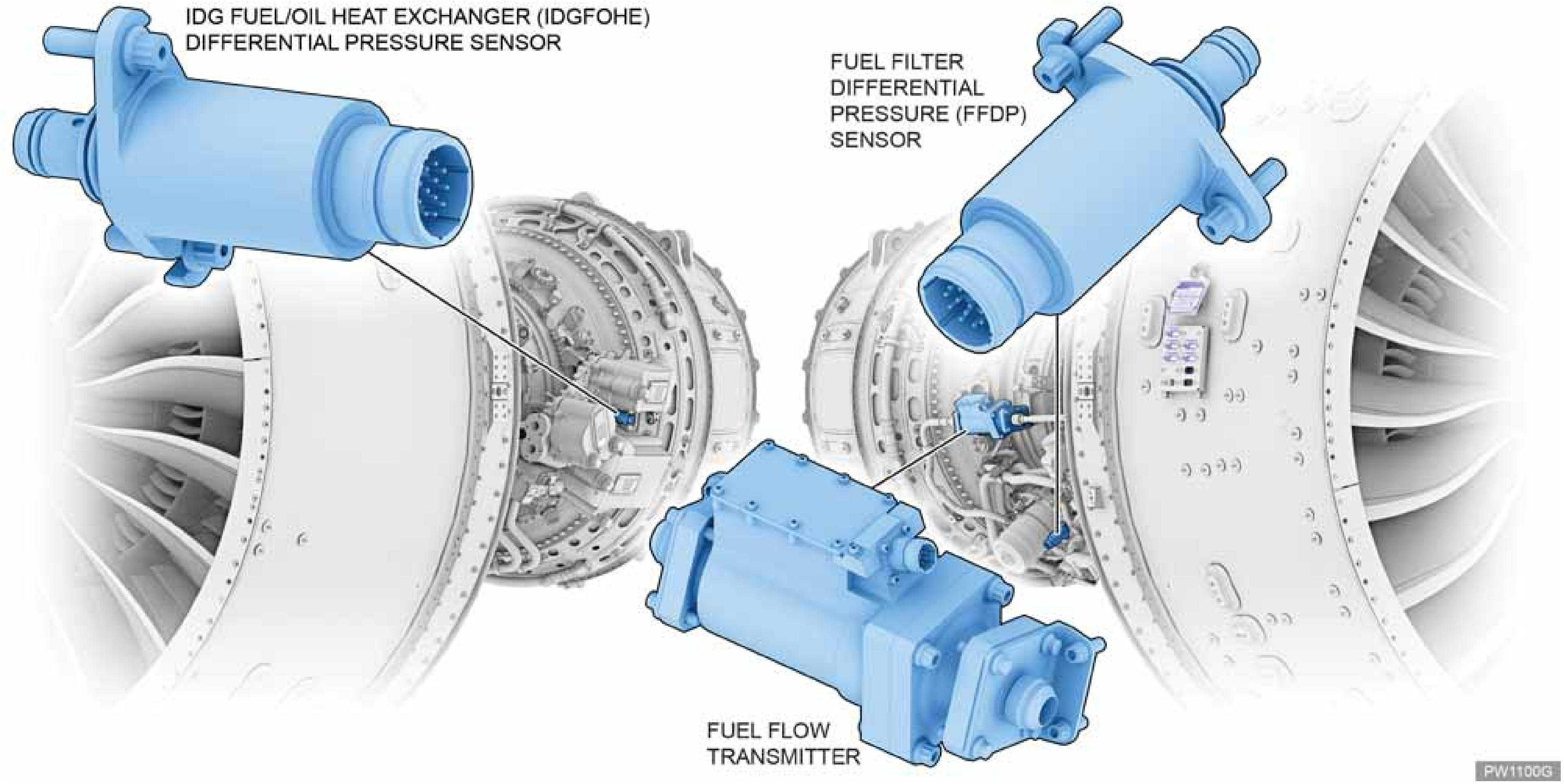
The system consists of the components shown below.

- Fuel flow transmitter
- Fuel Filter Differential Pressure sensor — FFDP
- Fuel temperature sensor — Tf
- IDG Fuel/Oil Heat Exchanger differential pressure sensor

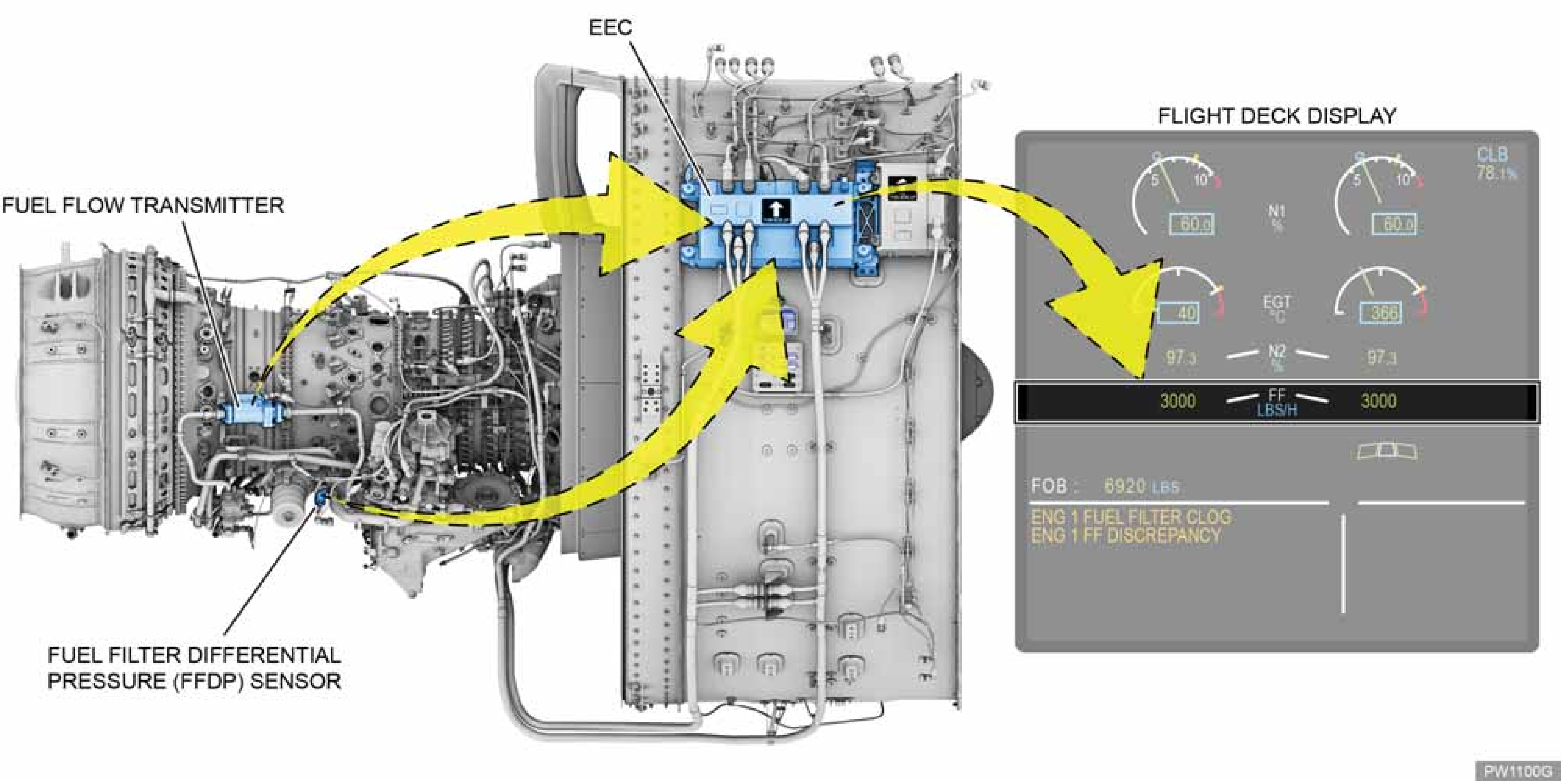
ENGINE / WARNING DISPLAY



PW1100G



FUEL INDICATING SYSTEM COMPONENTS



FUEL INDICATING SYSTEM OPERATION

FUEL INDICATING SYSTEM (Cont.)

Fuel Flow Transmitter

Purpose:

LRU

The fuel flow transmitter sends the EEC a signal that is used to calculate fuel flow to the combustor.

Location:

The fuel flow transmitter is at 3:00 on the right side of the engine.

Description:

The fuel flow transmitter is a single-element device wired to Channel A of the EEC. The signal is hardwired to Channel B internal to the EEC. The fuel flow transmitter is an in-line sensor located between the IFPC and the Fuel Flow Divider.

Operation:

1. Fuel enters the driver assembly, which provides the torque to rotate the shaft, drum and impeller. The vanes straighten the fuel flow and direct it to the rotating impeller.
2. The fuel flowing through the rotating impeller causes it to deflect proportionally against a spring. Impeller deflection relative to the drum is measured by pulses generated by magnets attached to the drum and impeller.

Safety Conditions

WARNING

DO NOT GET FUEL IN YOUR MOUTH, EYES, OR ON YOUR SKIN. DO NOT BREATHE THE FUMES FROM THE FUEL. KEEP THE FUEL AWAY FROM SPARKS, FLAME, AND HEAT. FUEL IS POISONOUS AND FLAMMABLE WHICH CAN CAUSE INJURIES TO PERSONS AND DAMAGE TO EQUIPMENT.

CAUTION

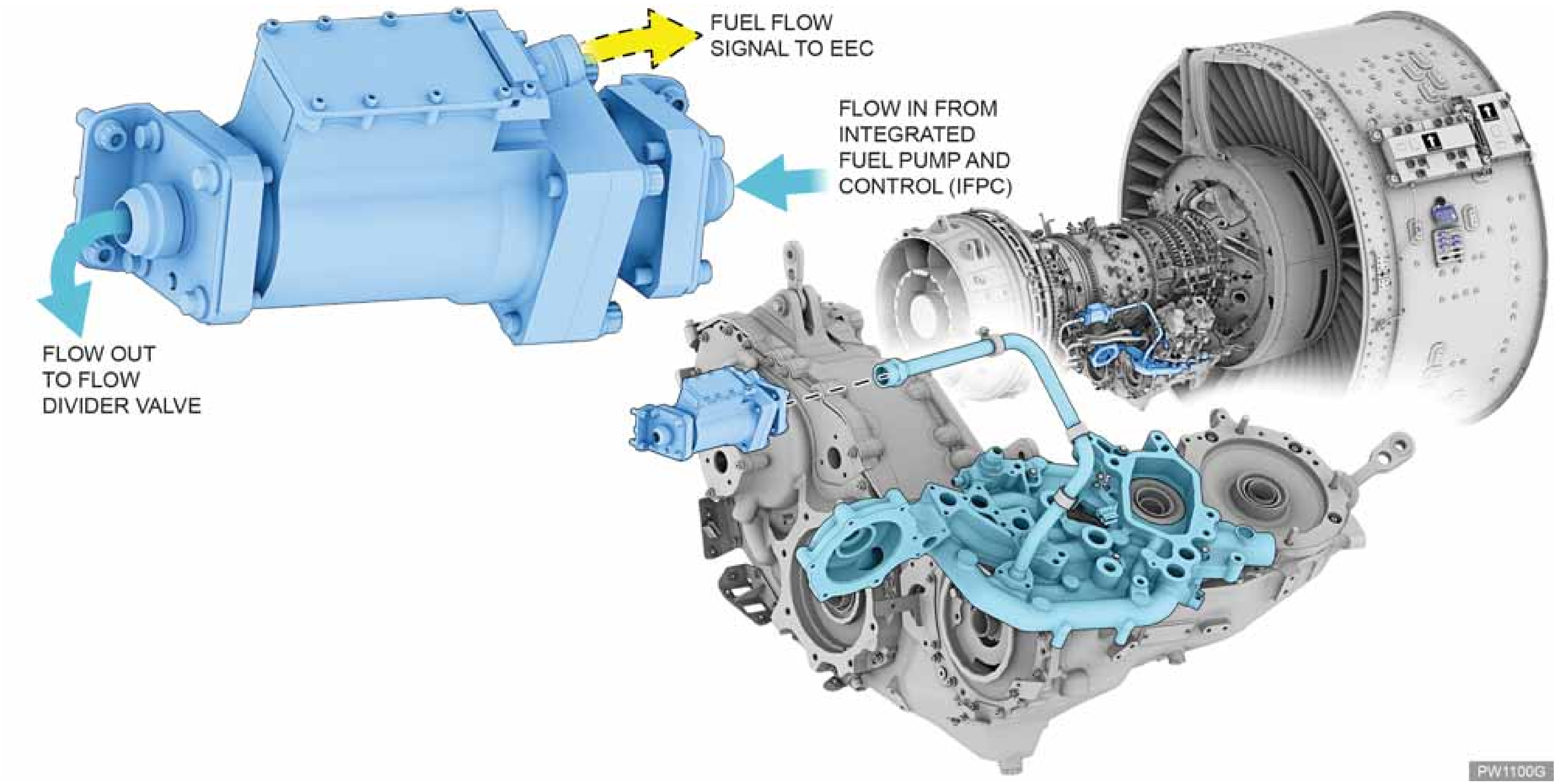
YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHT THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

DO NOT PRY ON THE RETENTION TAB TO REMOVE THE DRAIN PLUG. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE DRAIN PLUG.

DO NOT PUSH ON THE RETENTION TAB TO INSTALL THE DRAIN PLUG. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE DRAIN PLUG.

3. The pulses are converted at the electrical connector to an electronic signal that is sent to the EEC. The EEC then transmits the signal, in the form of fuel flow.
4. The EEC also computes fuel flow based on the fuel metering valve position and fuel temperature, and compares this calculated value to the value measured by the fuel flow transmitter. If the fuel flow measured by the fuel flow transmitter is determined to be invalid, the fuel flow indication in the cockpit is replaced by amber crosses.



FUEL INDICATING SYSTEM – FUEL FLOW TRANSMITTER

FUEL INDICATING SYSTEM (Cont.)

Fuel Filter Differential Pressure (FFDP) Sensor

Purpose: LRU PMT

The Fuel Filter Differential Pressure sensor alerts the crew of an impending filter clog by providing a signal to the EEC.

Location:

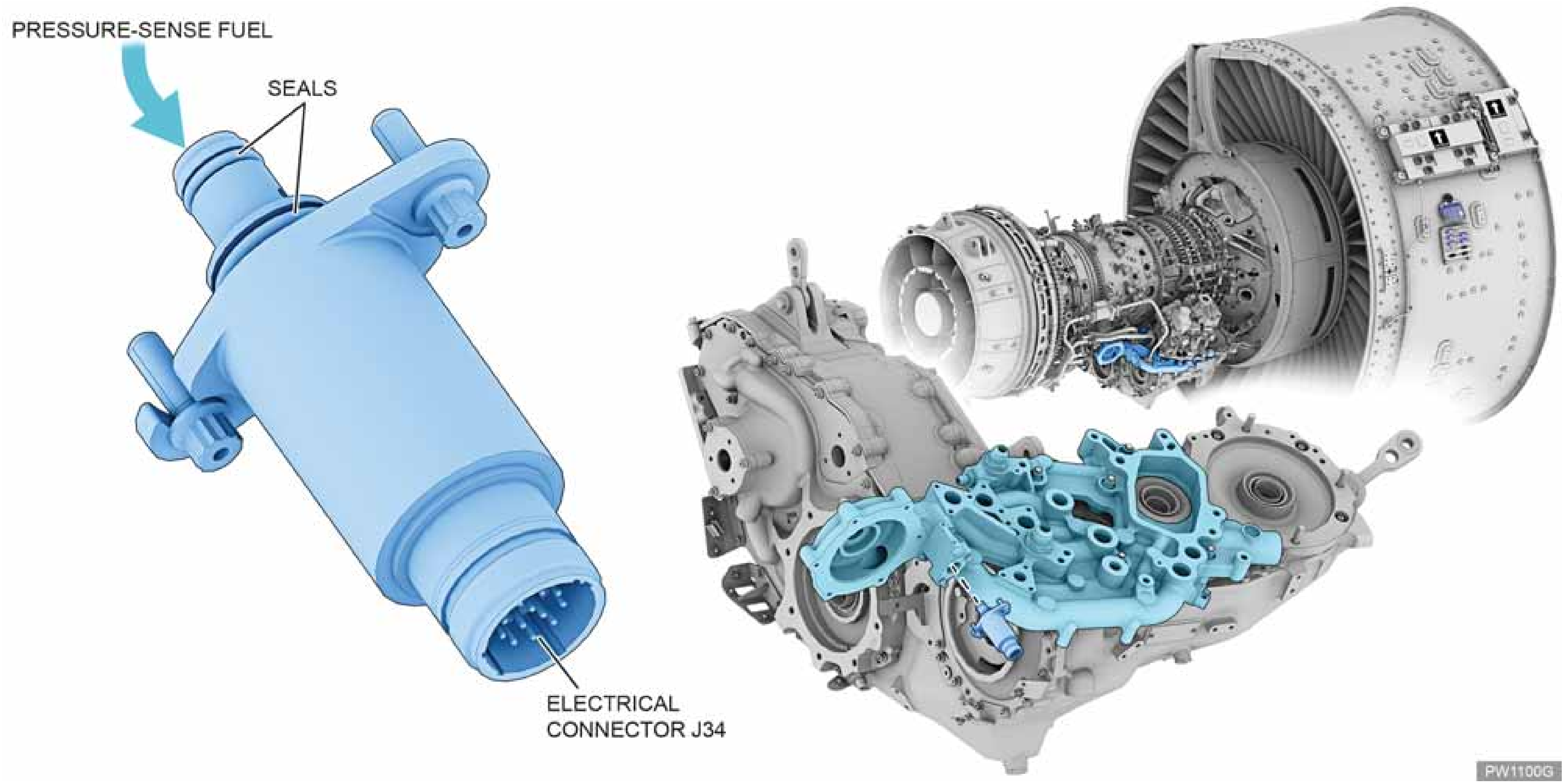
The sensor is mounted on the forward side of the fuel manifold next to the fuel filter at 5:00.

Description:

The dual-channel, differential pressure strain gage sensor has an offset clawfoot mount for fast, error-free maintenance.

Operation:

The FFDP measures differential pressure across the fuel filter. If the difference goes beyond design limits, the sensor issues an advisory signal to the flight deck display through the EEC.



FUEL INDICATING SYSTEM – FUEL FILTER DIFFERENTIAL PRESSURE (FFDP) SENSOR

FUEL INDICATING SYSTEM (Cont.)

IDG Fuel/Oil Heat Exchanger (IDGFOHE) Differential Pressure Sensor

Purpose: LRU PMT

The IDG Fuel/Oil Heat Exchanger differential pressure sensor measures the difference in fuel pressure upstream and downstream of the heat exchanger in order to detect fuel icing conditions.

Location:

The sensor is located at 9:00 on the heat exchanger manifold.

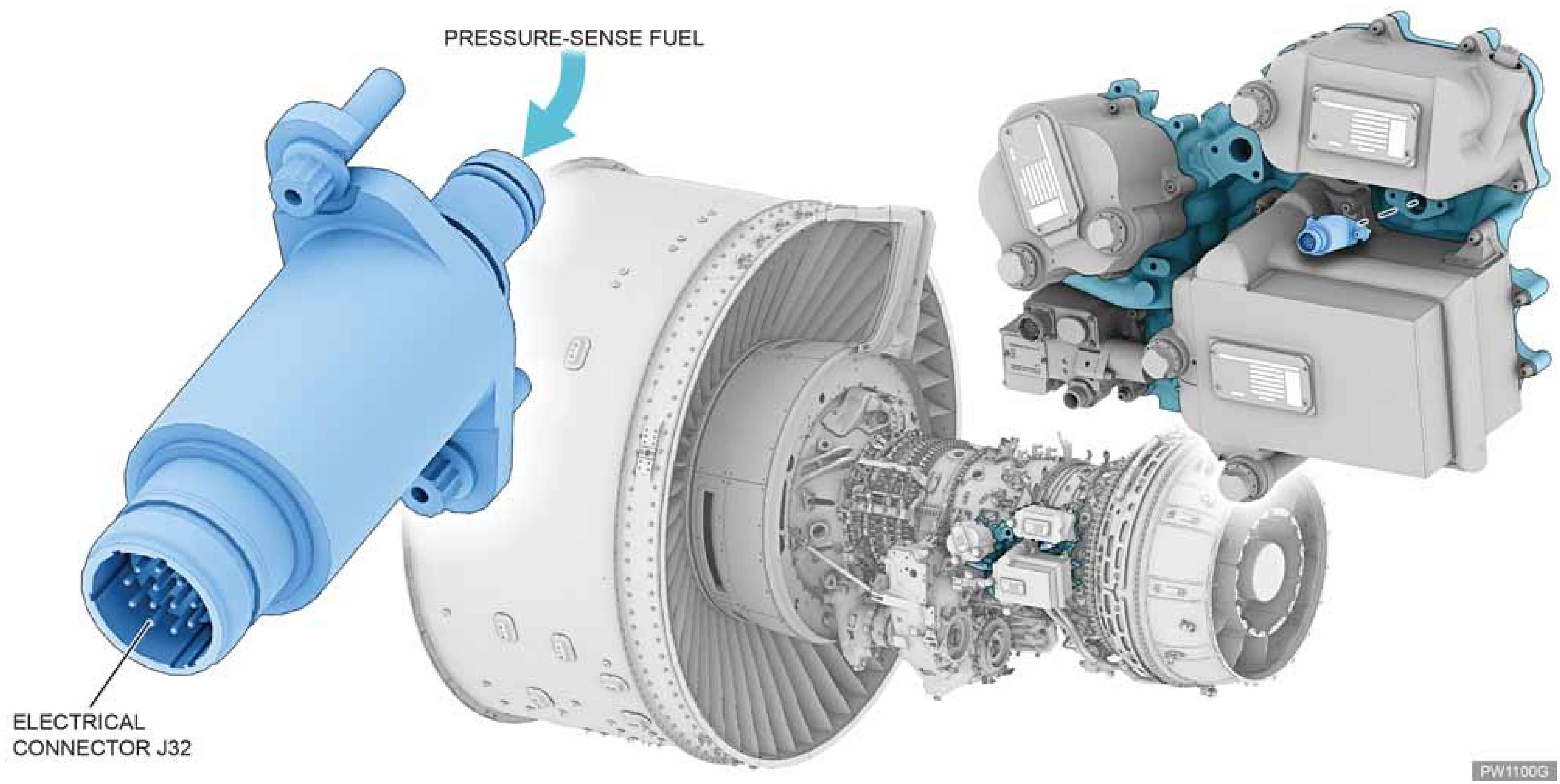
Description:

The sensor is dual channel.

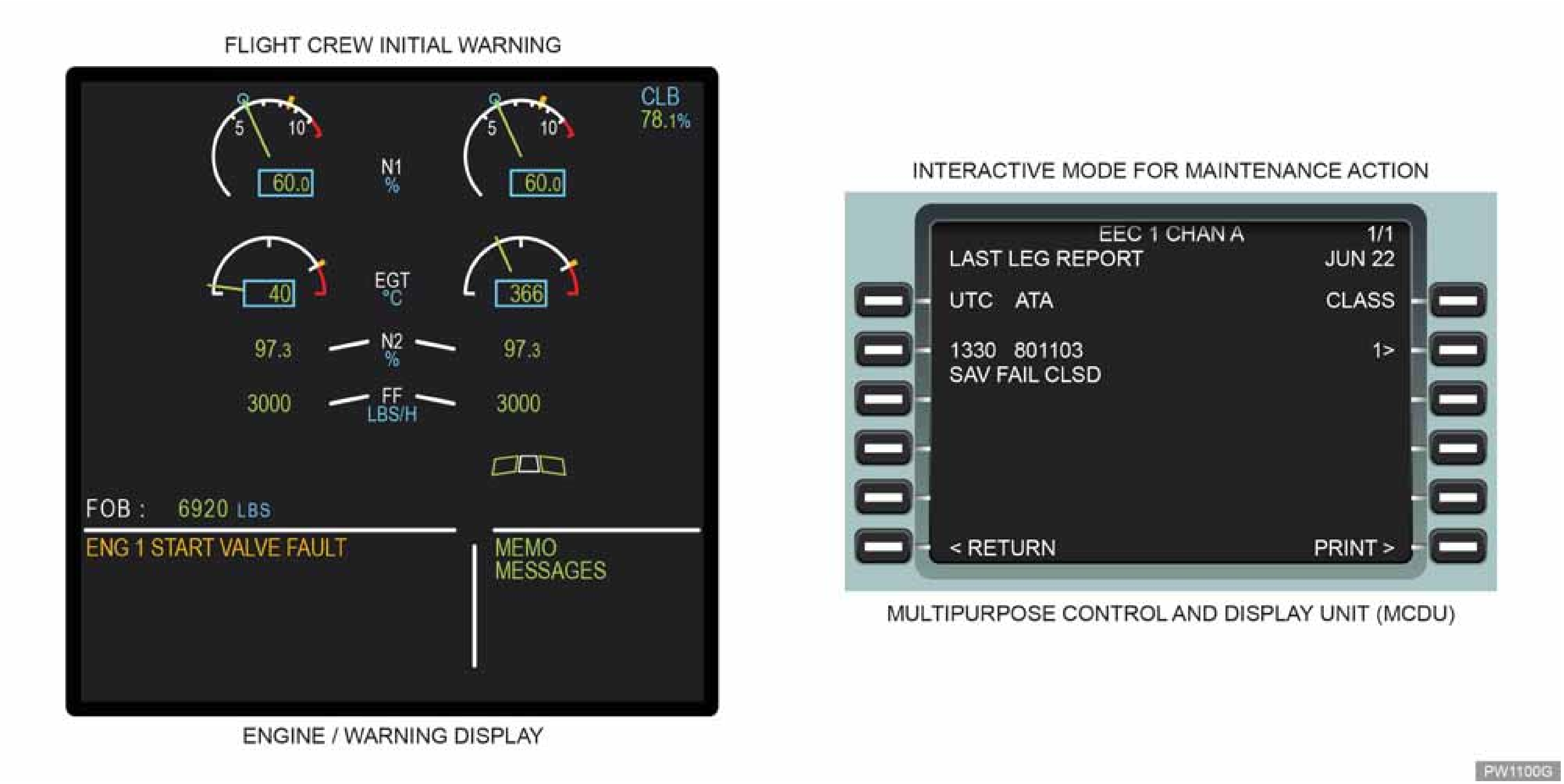
Operation:

When pressure is applied, the strain gages change resistance, altering the output voltage. The output voltage for each sensing element correlates directly to fuel pressure and is sent to the EEC.

The EEC uses the differential pressure signal to send an IDGOFHE impending bypass message. The message is dependent on the differential pressure value.



FUEL INDICATING SYSTEM – IDGFOHE DIFFERENTIAL PRESSURE SENSOR



SAMPLE ECAM MESSAGES FOR ATA 73

CHAPTER 4

AIR

ATA 75

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT ✓	A Post Maintenance Test is required.
WARNING	Avoid injury by following guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the five major functions of the Air System.

2. Locate system components.

3. Explain how the air systems below improve engine operations.

   - Compressor Variable Vane Control
   - Compressor Bleed Air
   - Turbine Cooling Air
   - Engine Bearing Cooling
   - Active Clearance Control

4. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Air System controls engine airflow to perform five major functions:

- increase engine operability and stability
- seal bearing compartments
- cool engine parts
- improve fuel efficiency
- remove ingested debris from the airstream.

The Air System is made up of five subsystems. Details are shown below, including air sources that are used to perform system functions.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

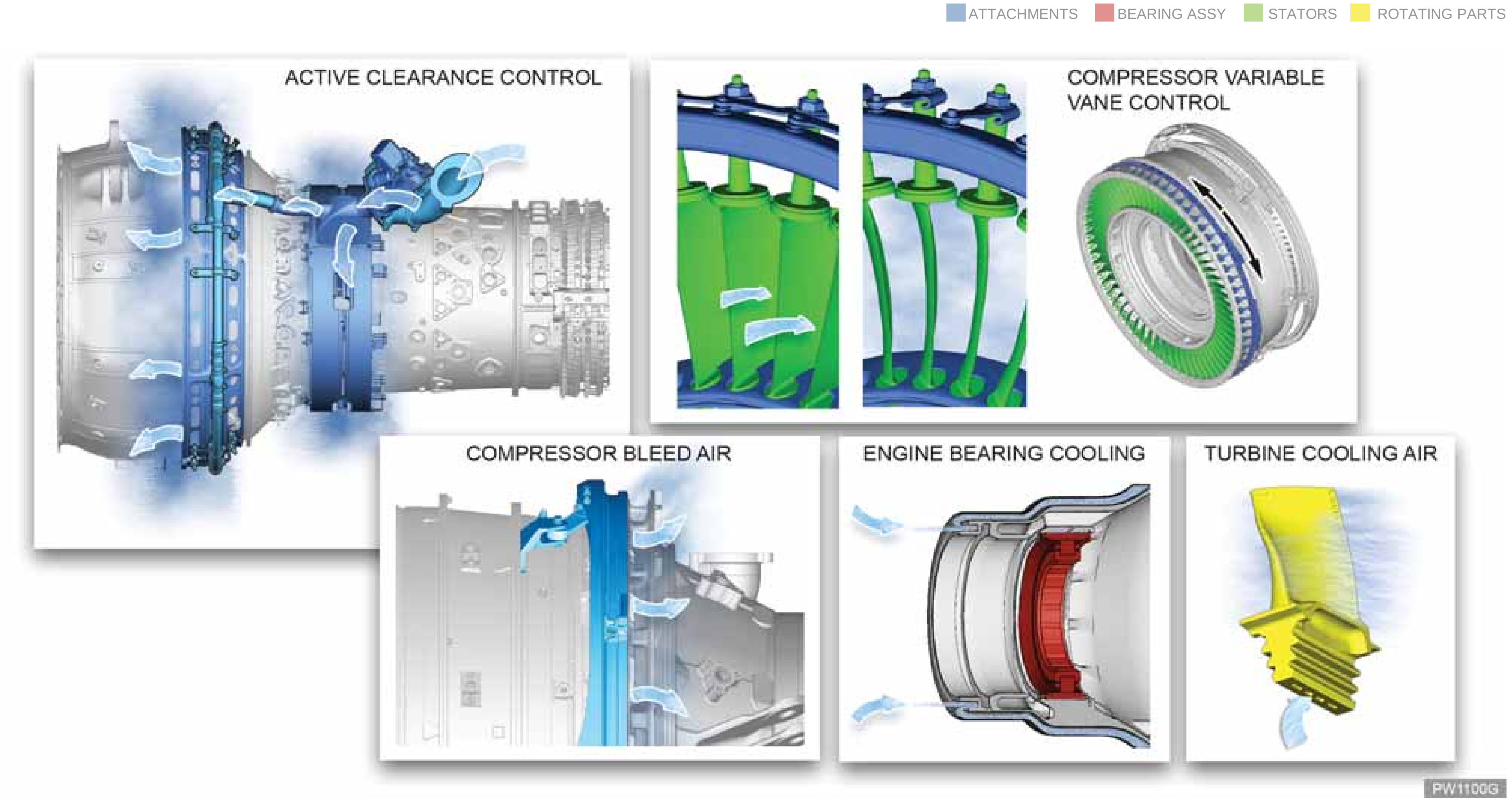
CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

OVERVIEW (Cont.)

System		Function	Air Source
Compressor Variable Vane Control	• LPC Variable Inlet Guide Vane Control • HPC Variable Vanes	Adjusts angle of compressor airflow to optimize performance, prevent surge, and improve starting	Primary airflow
Compressor Bleed Air	• 2.5 Bleed Valve Air System Assembly • HPC Bleed Air	Vents compressor air to increase stability, eliminate foreign object damage, and improve starting	Station 2.5 and HPC 6th Stage
Turbine Cooling Air		Provides continuous flow of HPC bleed air to cool HPT and LPT parts	HPC 3rd and 6th stages
Engine Bearing Cooling		Cools and seals bearing compartments	HPC 3rd Stage and Station 2.5
Active Clearance Control		Uses fan bypass air to cool HPT and LPT cases, reducing blade tip clearance for improved fuel efficiency	Fan



AIR SUBSYSTEMS

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

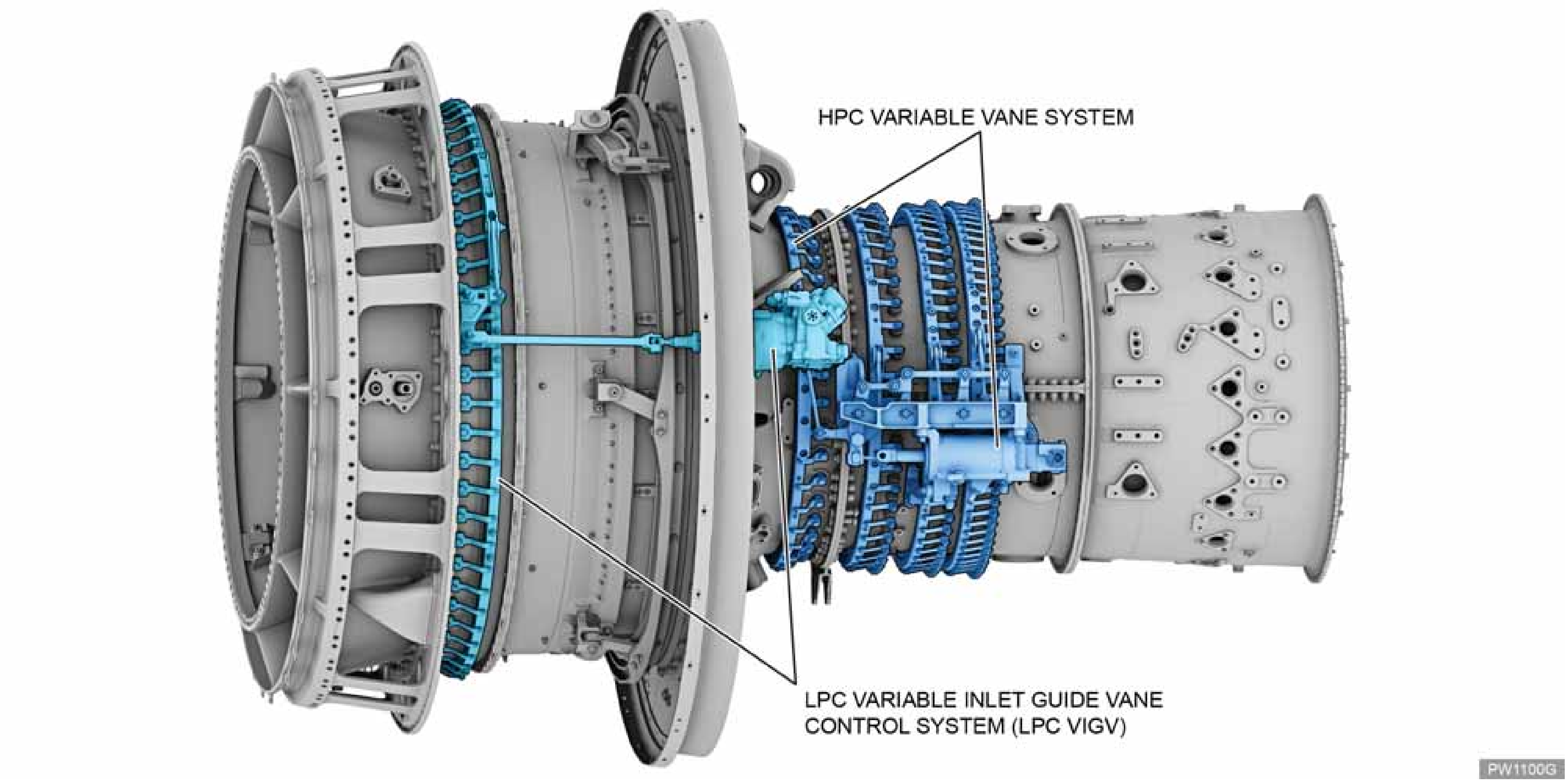
The Compressor Variable Vane Control System uses actuators to move the HPC and LPC Variable Inlet Guide Vanes (VIGVs), adjusting the angle of airflow required for optimal engine operation. The actuators receive commands from the EEC and are positioned hydraulically using pressure fuel (Pf) from the Integrated Fuel Pump and Control.

Subsystems include:

- Low Pressure Compressor Variable Inlet Guide Vane Control System
- High Pressure Compressor Variable Vanes System.

Both the LPC and HPC Variable Inlet Guide Vanes (VIGVs) use the actuators to change vane position via a bellcrank and linkages. The EEC commands the vanes using schedules based on rotor speeds, and uses fuel pressure to maintain engine stability.

The EEC also receives vane position feedback from Linear Variable Differential Transformers (LVDTs) mounted to the actuators. VIGVs for the LPC are positioned by a schedule based on N1 (LPC) speed. VIGVs for the HPC are positioned by a schedule based on N2 (HPC) speed.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM

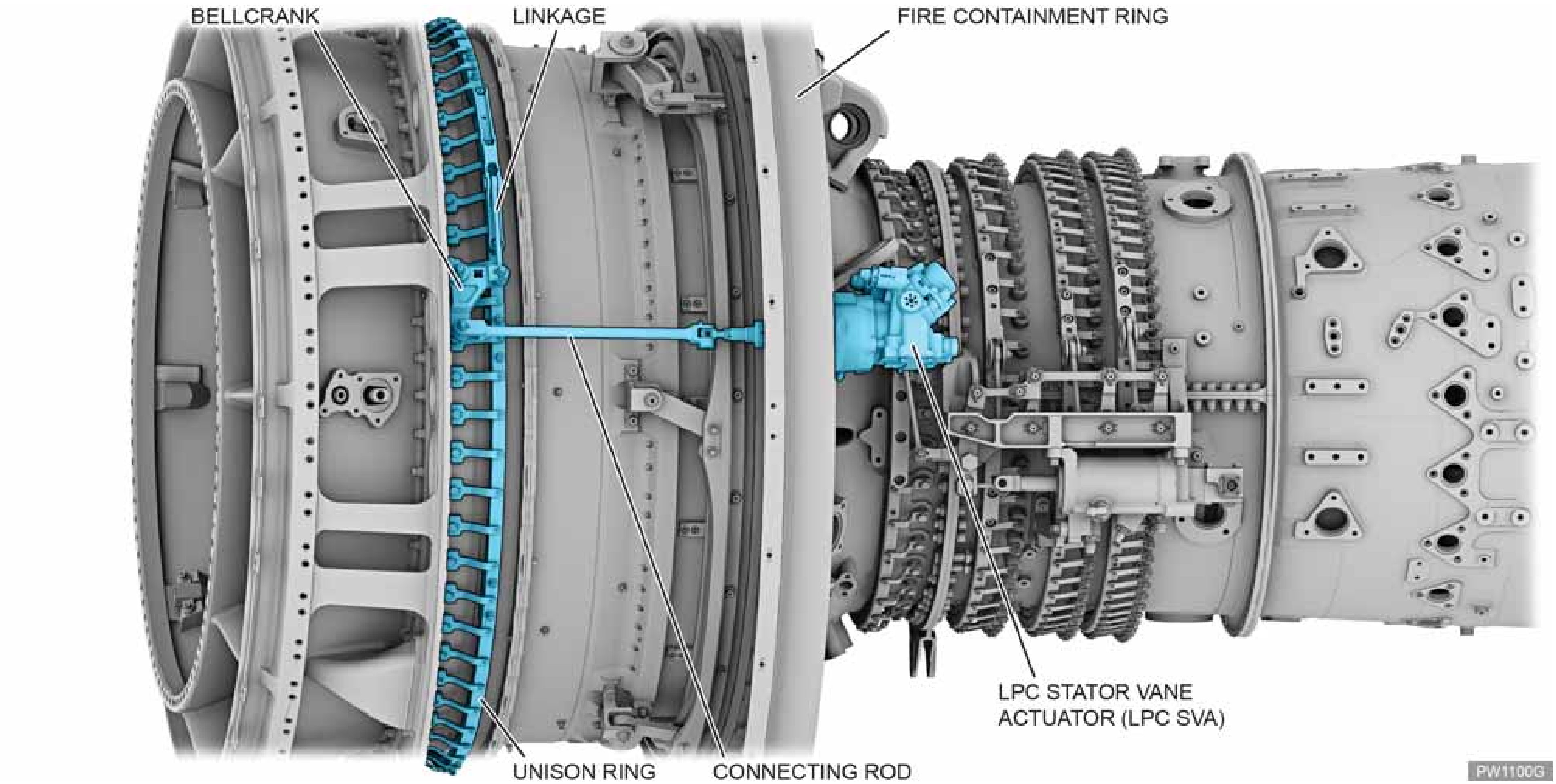
COMPRESSOR VARIABLE VANE CONTROL SYSTEM (Cont.)

Low Pressure Compressor Variable Inlet Guide Vane (LPC VIGV) Control System

Components for the LPC Variable Inlet Guide Vane Control system include:

- Stator Vane Actuator (SVA)
- bellcrank
- linkage
- connecting rod.

Condition	VIGV Position
Start	Open
Idle	Closed
Takeoff	Open
Climb	
Cruise	
Fail safe	
Descent	Closed
Thrust Reverse	



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – LPC VIGV CONTROL

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

Low Pressure Compressor Variable Inlet Guide Vane (LPC VIGV) Control System (Cont.)

LPC Stator Vane Actuator (SVA)

Purpose:

LRU PMT

The LPC SVA positions LPC variable inlet guide vanes through the LPC SVA linkage when commanded by the EEC.

Location:

The LPC SVA is mounted in the Compressor Intermediate Case fire containment ring on the left side of the engine at approximately 9:30.

Description:

A dual-channel LVDT is mechanically coupled to the actuator piston to provide electrically isolated position feedback signals to each channel of the EEC.

Safety Conditions

CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

Operation:

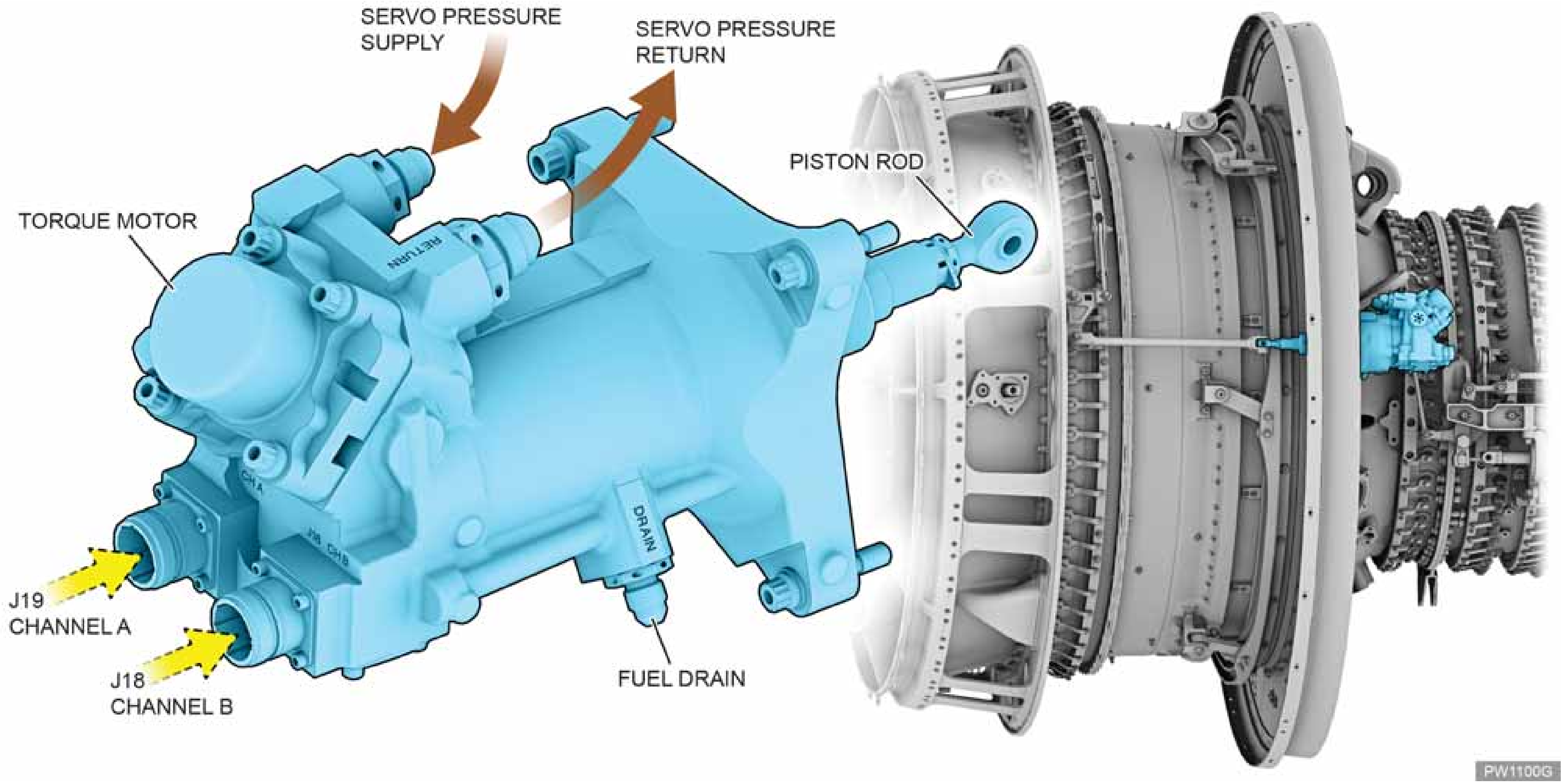
During engine operation, the EEC sends electrically isolated drive signals to the dual channel torque motor that is part of the LPC SVA. The drive signals direct pressurized fuel to either side of the actuator piston to achieve the commanded position.

If there is a loss of electrical power to the torque motor, the actuator positions the vanes in the full open fail safe position for maximum airflow through the LPC.

The actuator has a fuel drain for internal component leakage.

KEY FACT

LPC IGVs are open during engine startup and aircraft takeoff, and are closed during engine idle.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – LPC STATOR VANE ACTUATOR

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

Low Pressure Compressor Variable Inlet Guide Vane (LPC VIGV) Control System

LPC Stator Vane Actuator (SVA) (Cont.)

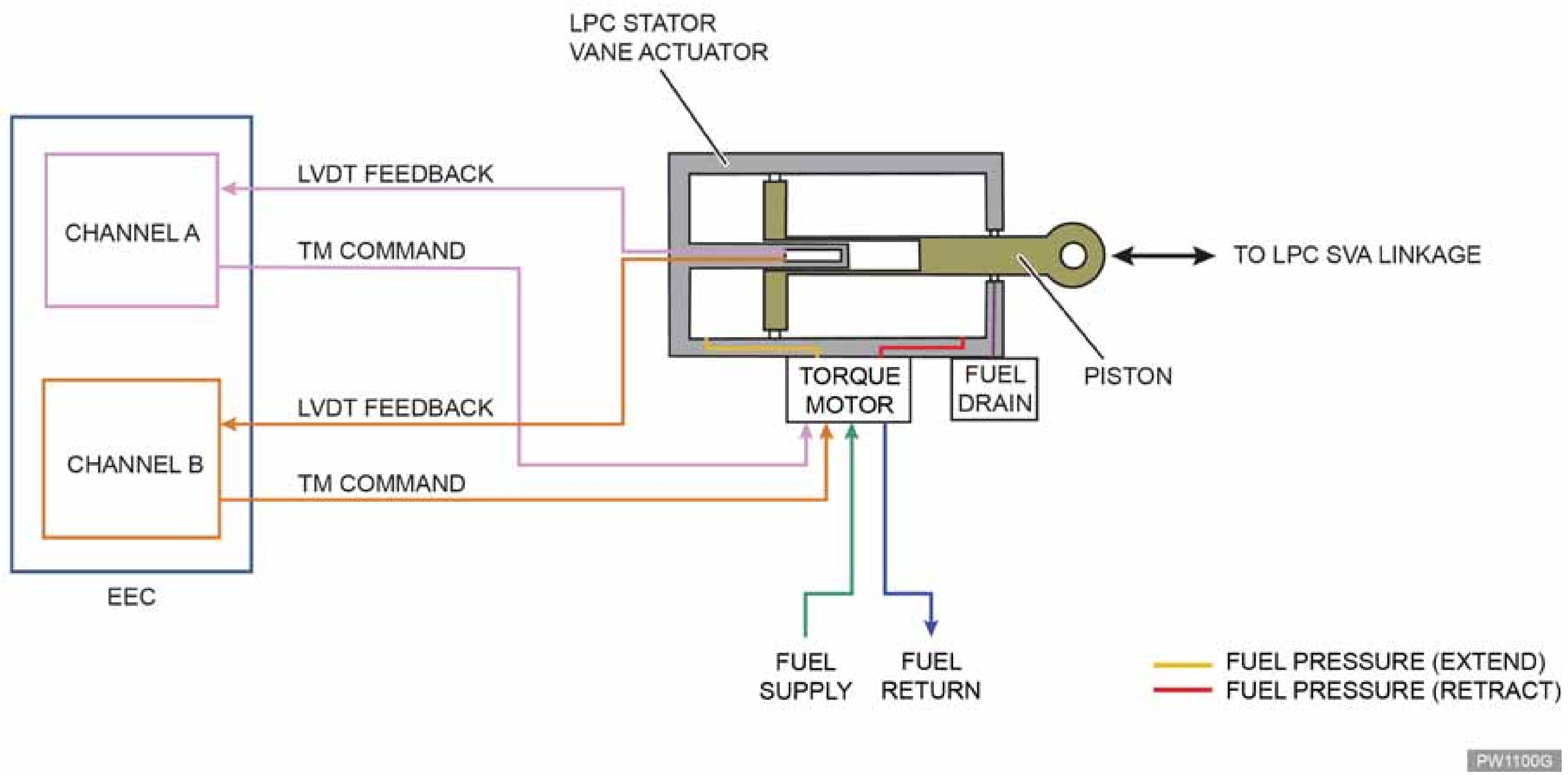
Operation:

1. Both channels of the EEC are capable of commanding the LPC SVA piston position through a dual-coil torque motor which controls a servo valve that distributes fuel servo pressure to either side of the piston.

2. The piston changes the position of the variable stator vanes through a bell crank, connecting rod, and linkage. The position of the LPC SVA piston rod is sensed by dual-coil Linear Variable Differential Transformers (LVDTs).

3. The LVDTs transmit the piston position to each EEC channel. If there is a power failure to the LPC SVA, the actuator positions the vanes in the open position for optimal airflow through the LPC. Vanes are positioned by a schedule based on N1 (LPC) speed.

The actuator has a fuel drain for internal component leakage.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – LPC VIGV CONTROL

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

Low Pressure Compressor Variable Inlet Guide Vane (LPC VIGV) Control System (Cont.)

LPC Variable Inlet Guide Vane (VIGV) Bellcrank and Linkage

Purpose: LRU

The LPC VIGV linkage translates the axial position movement of the LPC Stator Vane Actuator into circumferential synchronizing ring movement in order to position the 61 VIGVs.

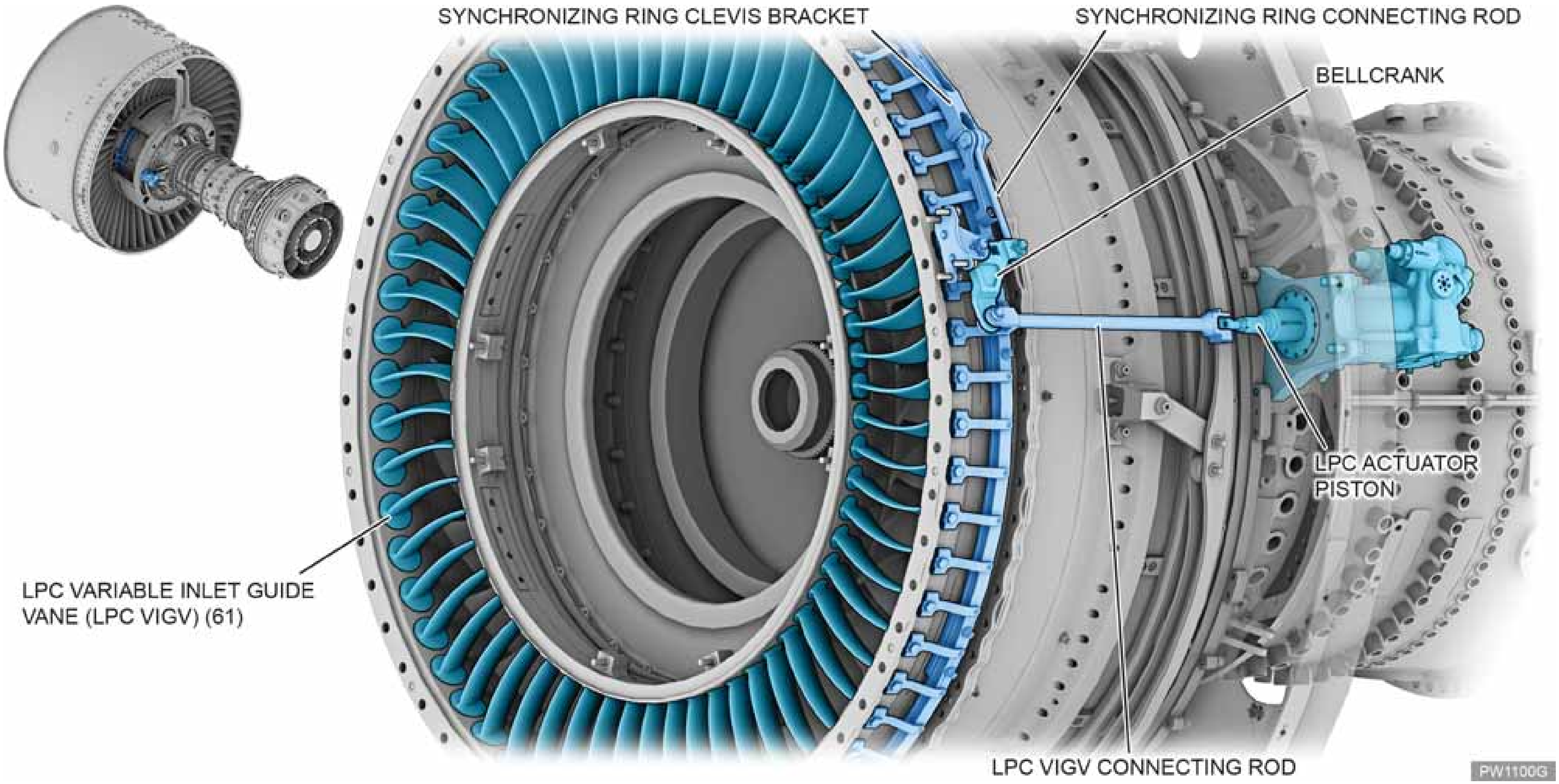
Location:

The linkage is located on the LPC case at 9:30.

Description:

The LPC SVA piston is attached the LPC connecting rod by a bolt through a clevis end. The forward end of the LPC connecting rod is bolted to the LPC bellcrank assembly.

The LPC bellcrank assembly is bolted to the bellcrank bracket. The bracket is attached to the Fan Intermediate Case by (FIC) four bolts.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – LPC VIGV BELLCRANK AND LINKAGE

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

Low Pressure Compressor Variable Inlet Guide Vane (LPC VIGV) Control System

LPC Variable Inlet Guide Vane (VIGV) Bellcrank and Linkage (Cont.)

Operation:

1. Upon receiving a command from the EEC, the LPC Stator Vane Actuator directs pressurized fuel to the appropriate side of the piston to move the LPC connecting rod.

2. The forward end of the LPC connecting rod moves the LPC bellcrank assembly, which pivots about the bellcrank bracket. This translates the axial movement of the LPC SVA into circumferential movement of the synchronizing rings. The rings move the 61 VIGVs in unison to the correct position.

Safety Conditions

CAUTION

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

COMPRESSOR VARIABLE VANE CONTROL SYSTEM (Cont.)

High Pressure Compressor Variable Vanes System

HPC Variable Stator Vane Actuators work in unison to position HPC Variable Inlet Guide Vanes and Variable Stator Vanes in response to EEC commands that optimize engine performance.

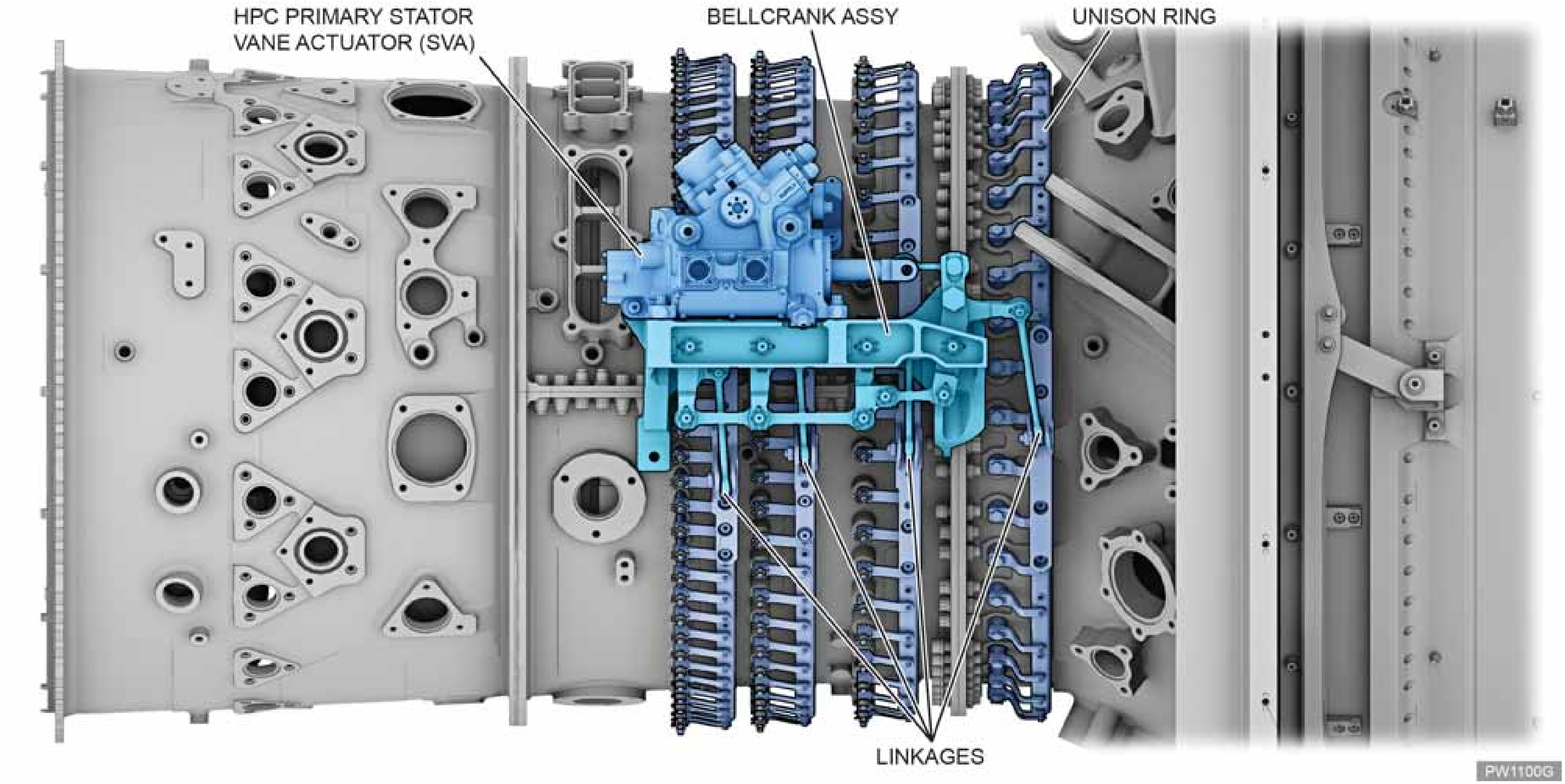
The system has primary and secondary stator vane actuators and adjusts the vanes using the HPC VIGV and VSV linkage.

A ¾-in. manual drive is machined into the SVA bellcrank to manually move the variable vanes.

Components for the HPC Variable Vanes System include:

- stator vane actuators (2)
  - primary
  - secondary
- bellcrank
- linkages (4).

Condition	VSV Position
Start	Closed
Idle	
Takeoff	Open
Climb	
Cruise	
Fail safe	
Descent	Closed
Thrust Reverse	



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – HPC VIGV CONTROL – RIGHT SIDE

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

High Pressure Compressor Variable Vanes (Cont.)

HPC Primary Stator Vane Actuator (SVA)

Purpose:

LRU PMT

The HPC primary Stator Vane Actuator positions the inlet guide vanes of the Compressor Intermediate Case and HPC variable vane stages 1–3.

Location:

The primary actuator is mounted on the HPC case on the right side at 2:00.

Description:

The primary SVA is a dual-channel, EEC-controlled valve with a fuel actuated piston that moves the HPC bellcrank assemblies. Piston position feedback is provided to Channel A of the EEC.

A seal drain fitting provides an attachment point for a drain tube in the event of a internal leak of actuator seals. Removal and replacement of the actuator requires no adjustments to the new component or the system.

Safety Conditions

CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

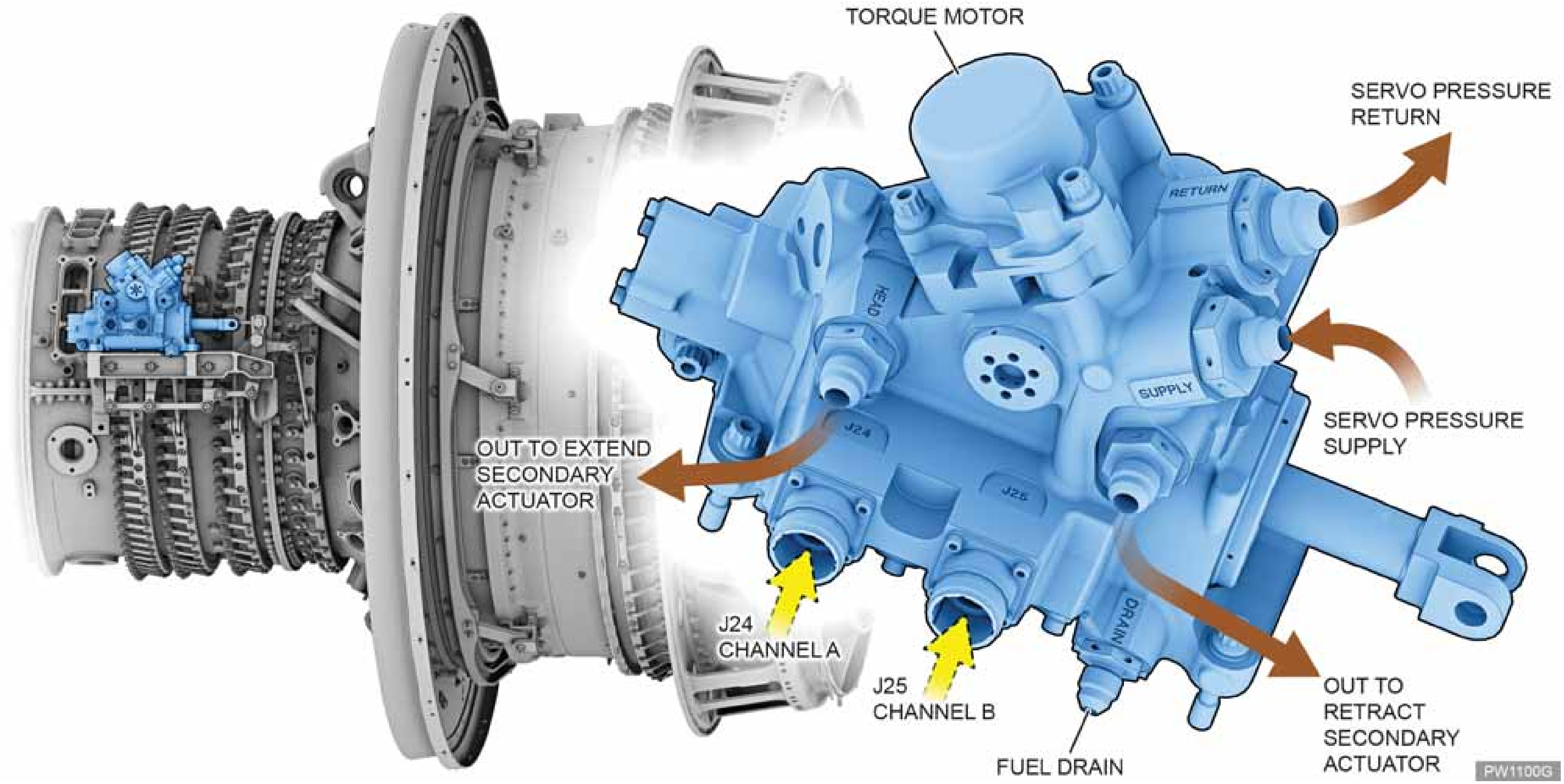
Operation:

During engine operation, the EEC sends electrically isolated drive signals to the dual-channel torque motor that is part of the primary SVA. The torque motor uses the electrical signals to direct pressurized fuel to either side of the actuator piston to achieve the actuator position.

A single-channel LVDT is mechanically coupled to each actuator piston to provide a positional feedback signal to the EEC.

If there is a loss of electrical power to the torque motor, the actuator positions the vanes to the full open fail-safe position for maximum airflow through the HPC.

The EEC can use either the primary or secondary actuator LVDT feedback signals to control the system.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – HPC PRIMARY STATOR VANE ACTUATOR

COMPRESSOR VARIABLE VANE CONTROL SYSTEM

High Pressure Compressor Variable Vanes (Cont.)

HPC Secondary Stator Vane Actuator (SVA)

Purpose:

LRU PMT

The HPC secondary Stator Vane Actuator positions the inlet guide vanes of the Compressor Intermediate Case and the 1st, 2nd and 3rd variable vanes of the HPC.

Location:

The secondary actuator is on the left side of the HPC at 9:00.

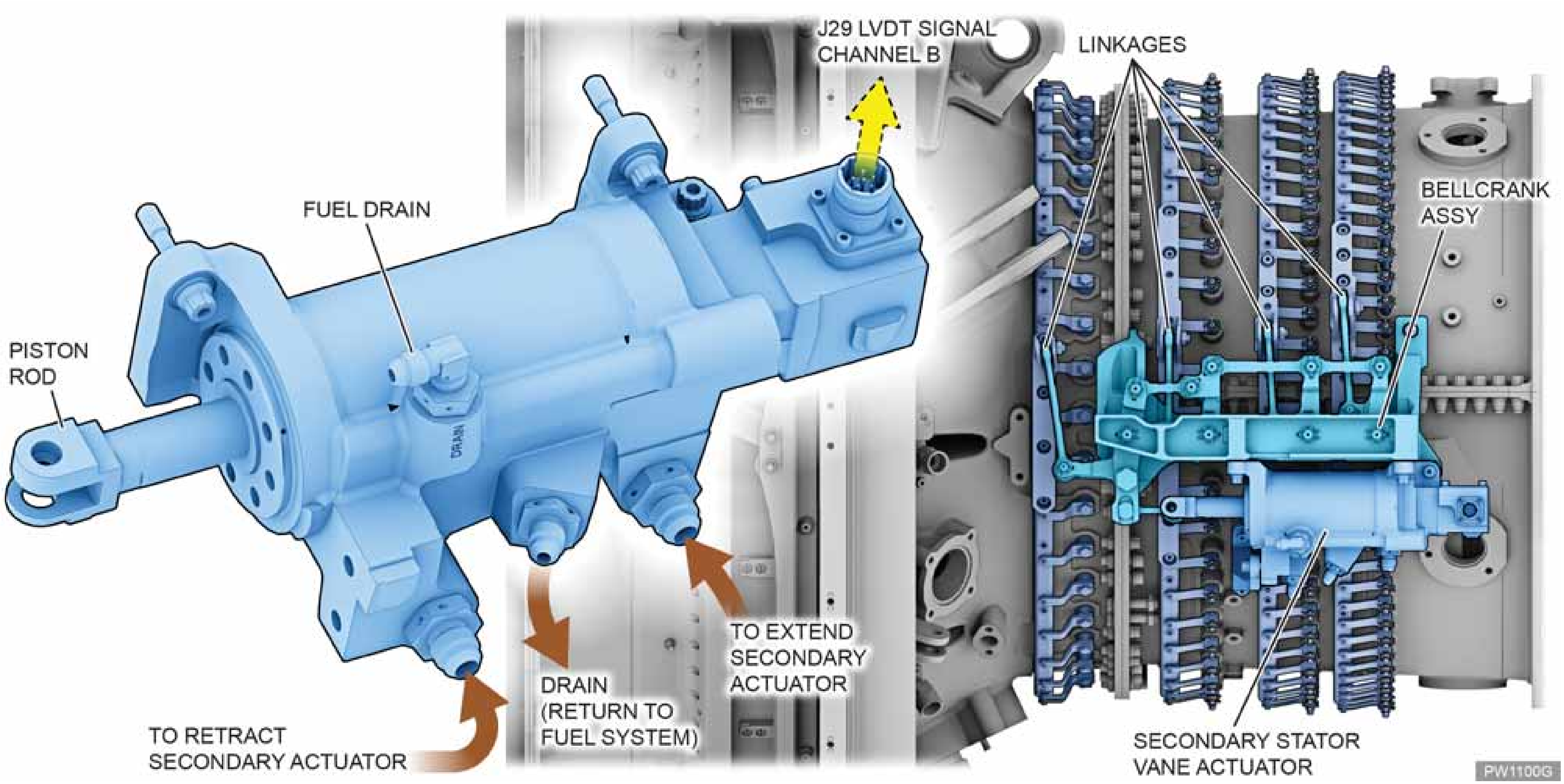
Description:

The secondary SVA is a dual-channel, EEC-controlled valve with a fuel actuated piston that moves the HPC bellcrank assemblies. Piston position feedback is provided to Channel B of the EEC through the secondary LVDT.

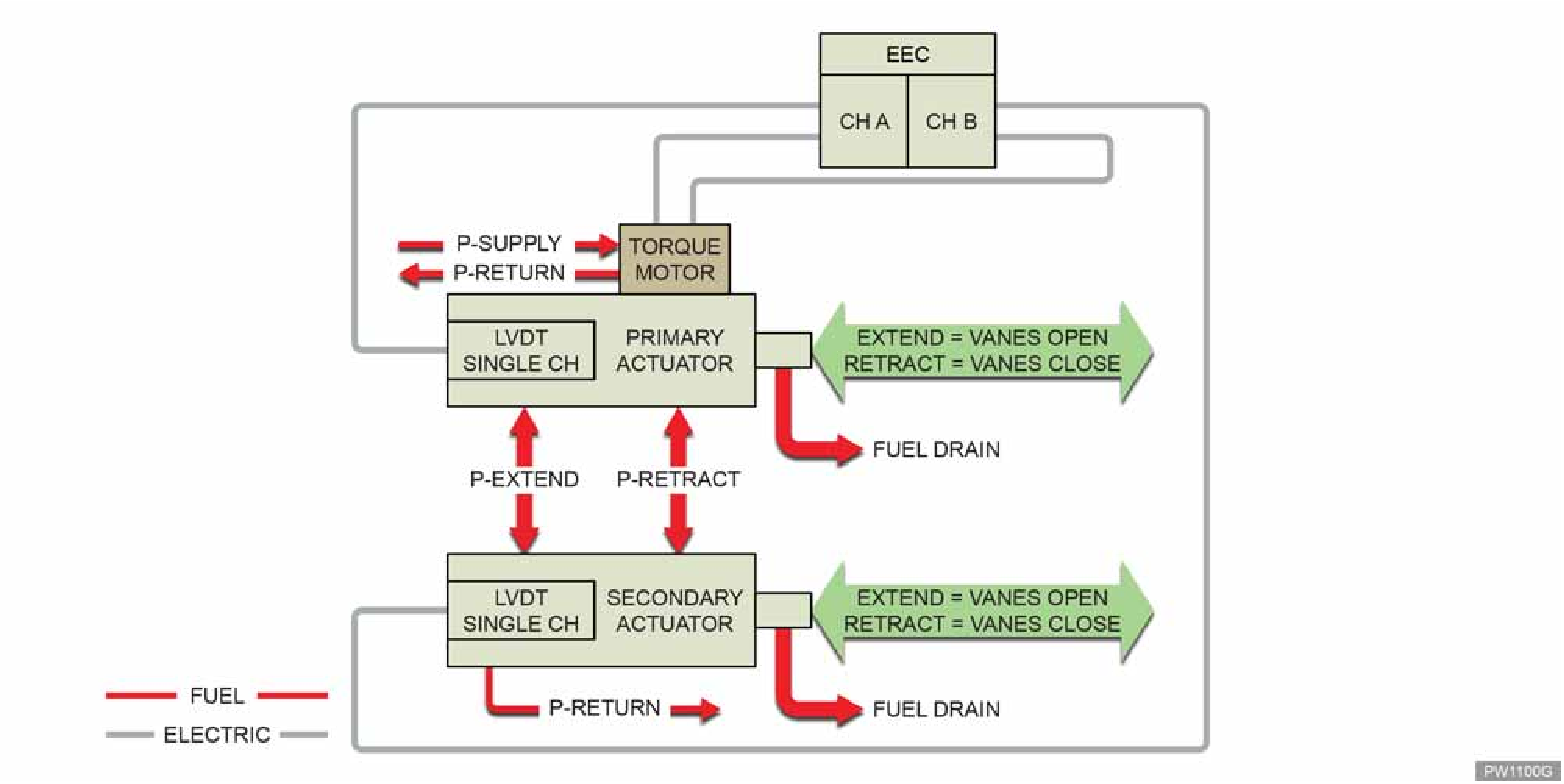
Operation:

Pressurized fuel from the primary SVA is routed via a fuel supply and fuel return tubes to the HPC secondary SVA, positioning the HPC secondary actuator piston.

The EEC uses primary and secondary actuator LVDT feedback signals to control the system.



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – HPC SECONDARY STATOR VANE ACTUATOR



COMPRESSOR VARIABLE VANE CONTROL SYSTEM – HPC SVA ELECTRICAL CONTROL

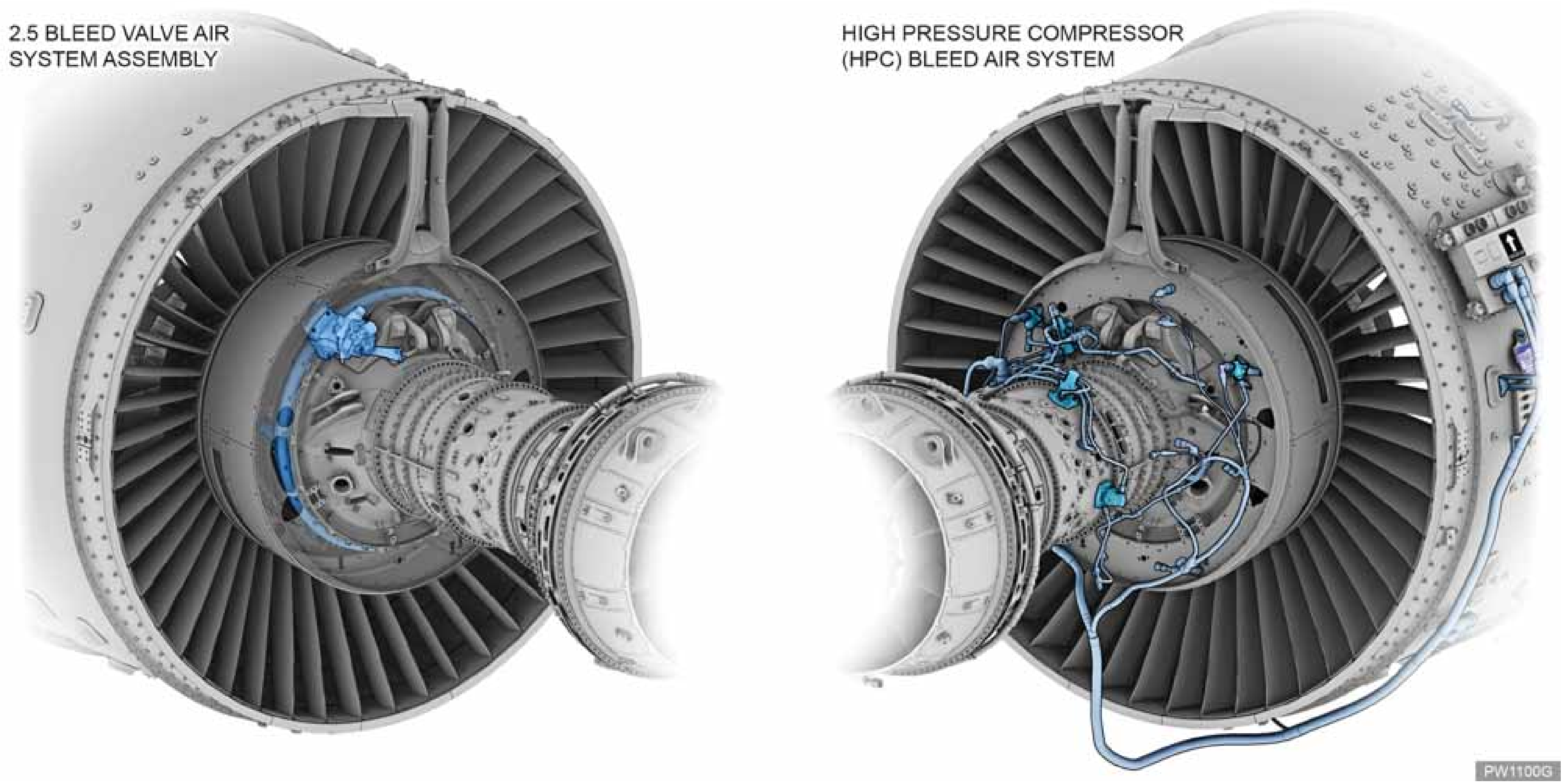
COMPRESSOR BLEED AIR SYSTEM

The Compressor Bleed Air System improves engine operability and stability by bleeding air from the low and high pressure compressors.

The system also removes debris from the LPC air stream.

The Compressor Bleed Air System consists of the following:

- 2.5 Bleed Valve Air System Assembly
- High Pressure Compressor (HPC) Bleed Air System.



COMPRESSOR BLEED AIR SYSTEM

COMPRESSOR BLEED AIR SYSTEM (Cont.)

2.5 Bleed Valve Air System Assembly

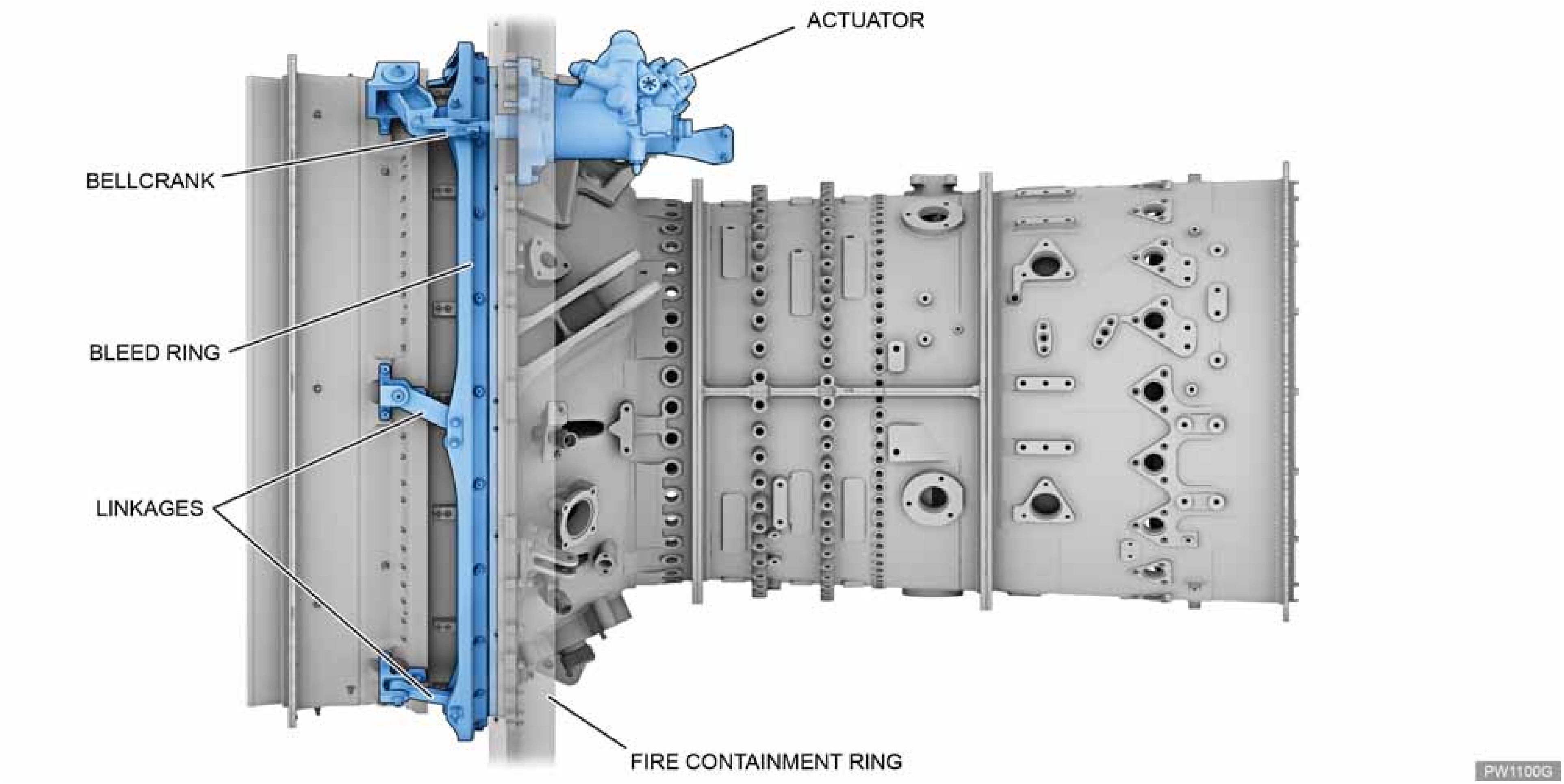
The 2.5 Bleed Valve Air System Assembly discharges LPC exit airflow into the fan bypass airstream to improve engine operability and stability when commanded by the EEC.

Assembly components are shown below.

- Bleed ring
- Actuator
- Bellcrank
- Linkages (5)

The system is attached to the LPC Assembly just forward of the CIC. An actuator mounted on the fire containment ring modulates the position of the bleed valve. The bleed valve is open at start and idle, and closed at take-off power.

Condition	Valve Position
Start	Open
Idle	
Takeoff	Closed
Climb	
Cruise	
Fail safe	Open
Descent	
Thrust Reverse	



COMPRESSOR BLEED AIR SYSTEM – 2.5 BLEED VALVE AIR SYSTEM ASSEMBLY

COMPRESSOR BLEED AIR SYSTEM

2.5 Bleed Valve Air System Assembly (Cont.)

2.5 Bleed Valve Actuator

LRU PMT

Purpose:

The 2.5 Bleed Valve Actuator (BVA) controls the LPC bleed valve through the 2.5 bleed valve linkage when commanded by the EEC.

Location:

The actuator is mounted at the rear of the CIC fire containment ring at approximately 11:00.

Description:

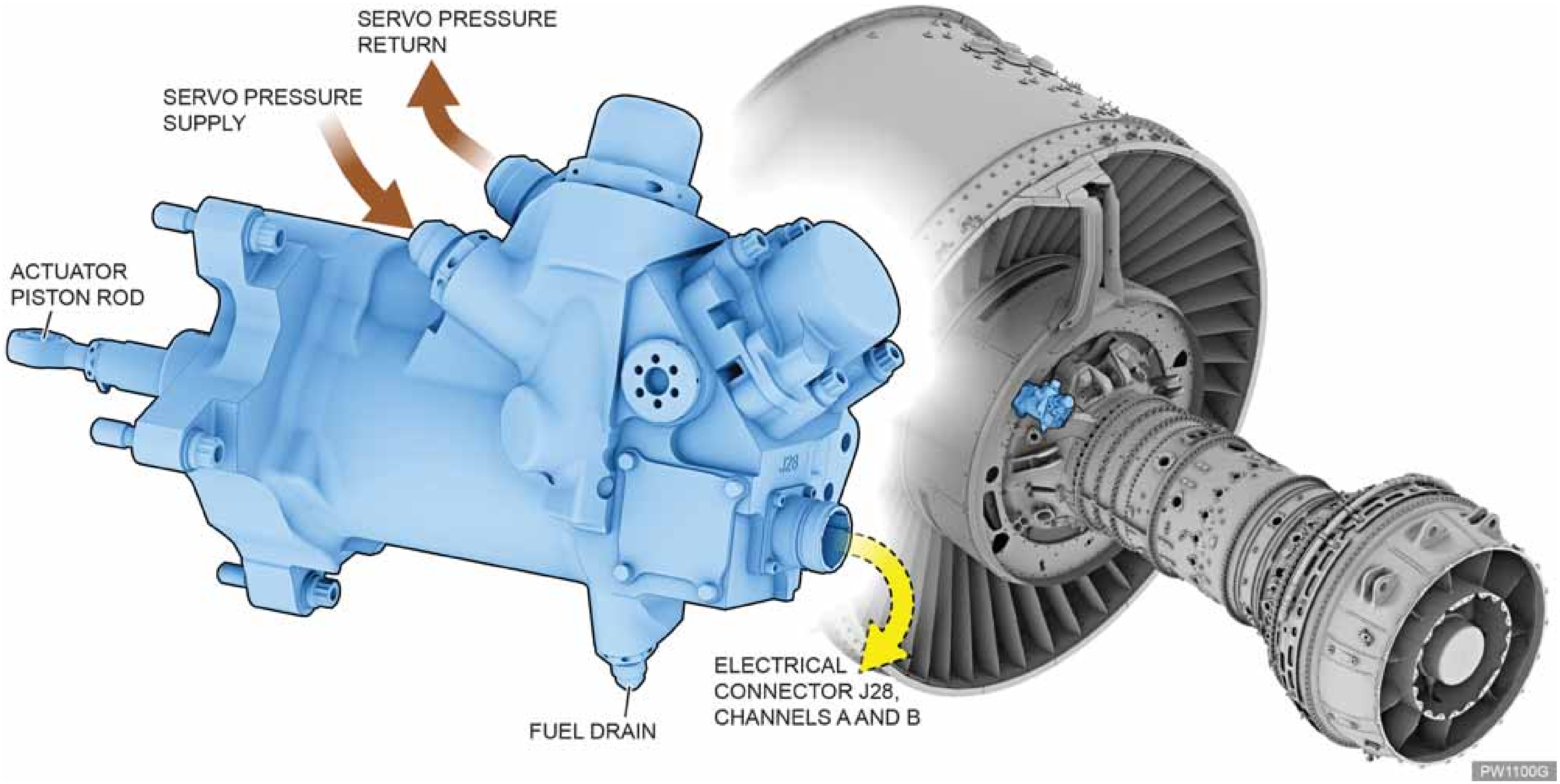
A dual-channel LVDT is mechanically coupled to the actuator piston to provide position feedback signals to each channel of the EEC.

The actuator is connected to the EEC by an electrical harness and is hydraulically actuated by fuel. It has fittings for servo pressure, servo pressure return, and seal drain.

The actuator is scheduled based on corrected N1 (Low Pressure Compressor) speed. No adjustment is required.

The BVA includes a load-limiting valve for these purposes:

- regulate the pressure of the head of the actuator
- limit the extend force applied to the actuator piston.



COMPRESSOR BLEED AIR SYSTEM – 2.5 BLEED VALVE ACTUATOR

COMPRESSOR BLEED AIR SYSTEM

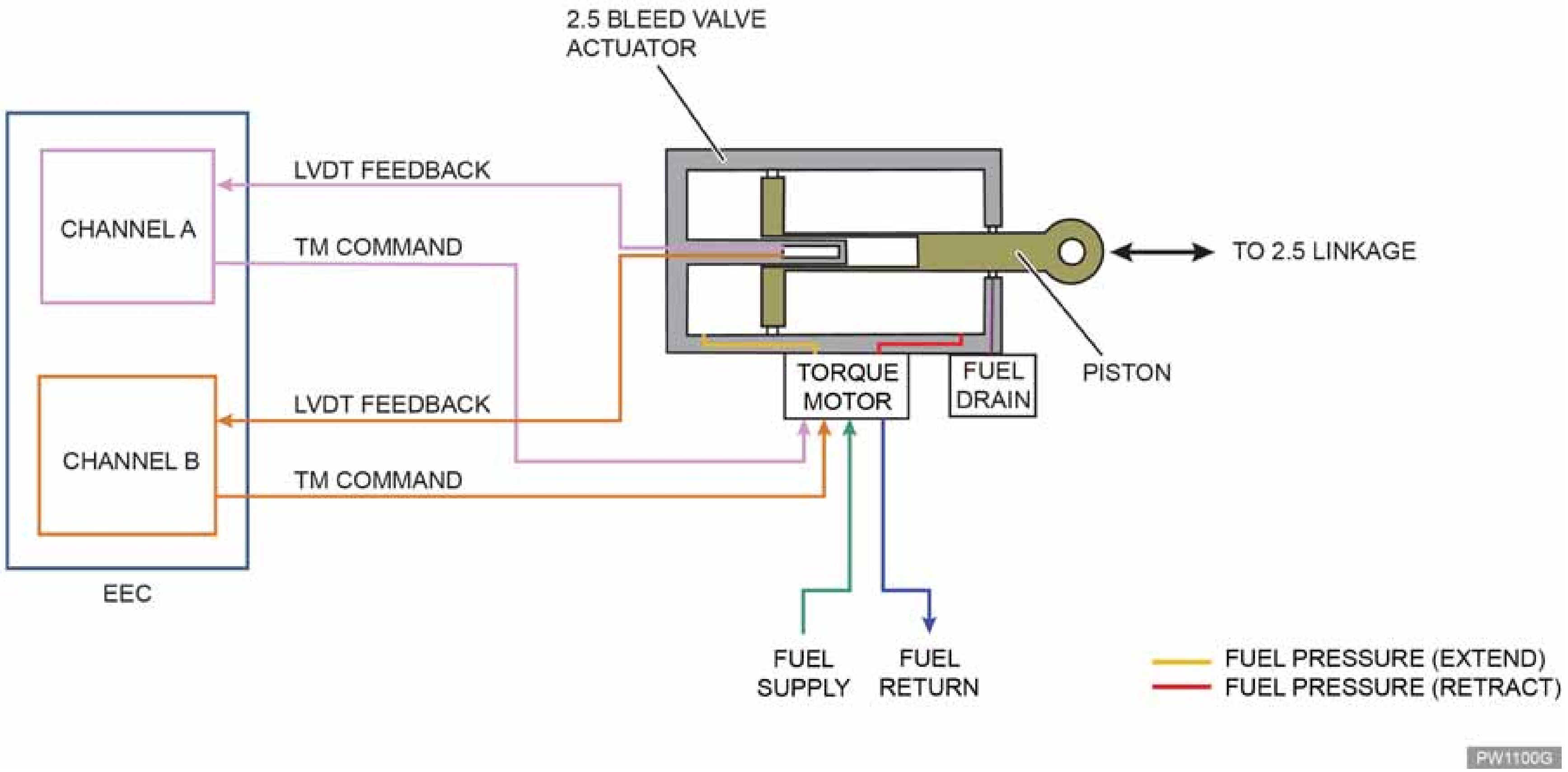
2.5 Bleed Valve Air System Assembly

2.5 Bleed Valve Actuator (Cont.)

Operation:

During engine operation, the EEC sends electrical signals to a dual channel torque motor that is part of the BVA. The torque motor uses the electrical signals to direct pressurized fuel to either side of the actuator piston to achieve the commanded position.

If there is a loss of power, the actuator positions the bleed valve in the full open fail safe position for maximum bleed air flow.



COMPRESSOR BLEED AIR SYSTEM – 2.5 BLEED VALVE ACTUATOR OPERATION

COMPRESSOR BLEED AIR SYSTEM

2.5 Bleed Valve Air System Assembly (Cont.)

2.5 Bleed Valve Linkage

Purpose: LRU

The 2.5 bleed valve linkage translates axial movement of the 2.5 BVA piston to circumferential movement to open and close the bleed valve.

Location:

The 2.5 bleed valve linkage is located at 11:00 on the LPC case.

Description:

The bleed valve connecting link is bolted to the 2.5 BVA piston at one end and to the bleed valve bellcrank at the other end. The bleed valve bellcrank is also attached to the bleed valve by one bolt and is fastened to the bellcrank support bracket with one bolt and washer. The bellcrank support bracket is mounted to the LPC outer case by two bolts.

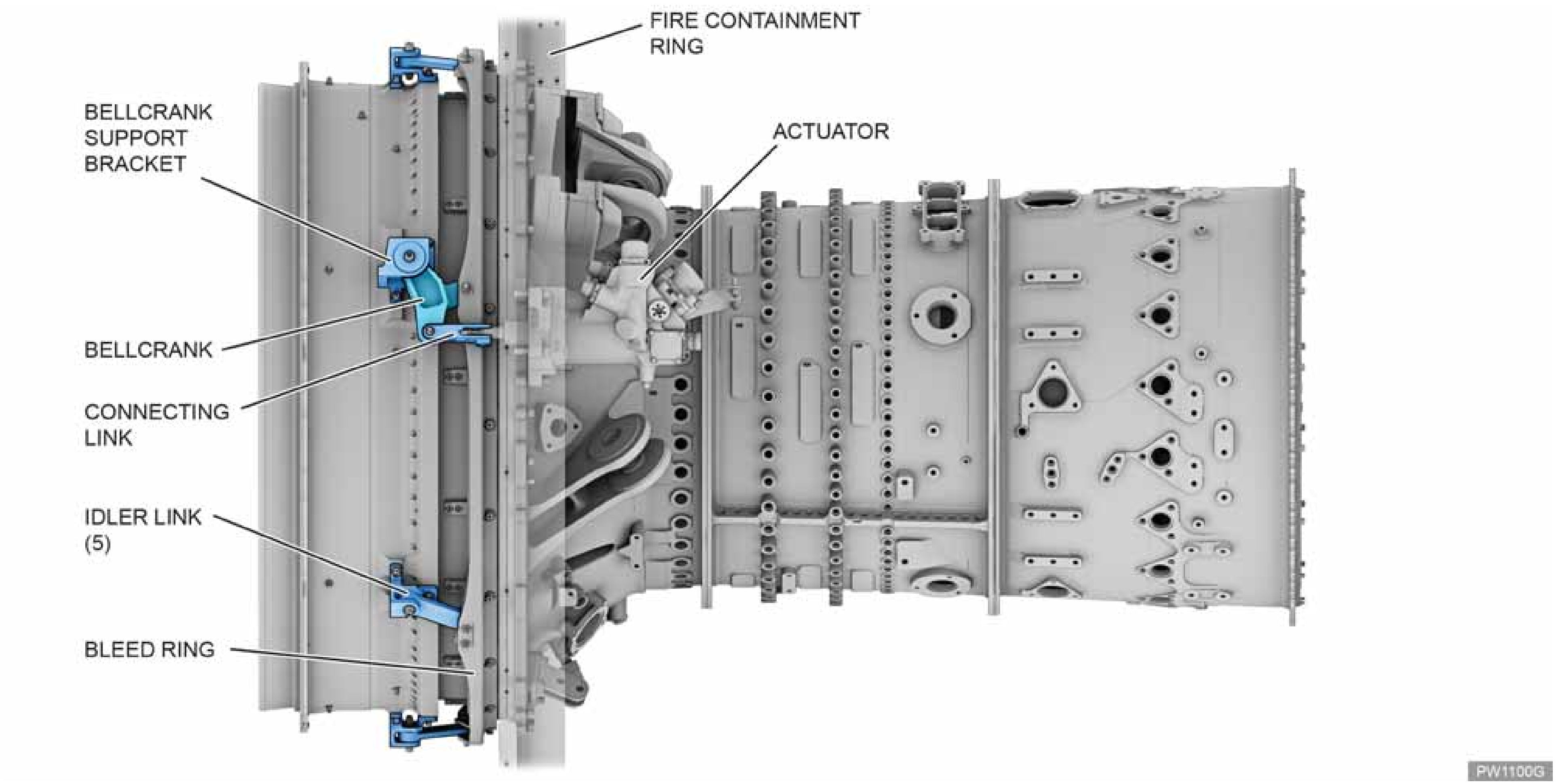
Two fabric-coated, silicone seal rings are installed on the bleed valve to provide sealing when the bleed valve is in the closed position.

Connecting links support the bleed valve around the circumference of the CIC.

Operation:

Forward and aft movement of the actuator piston is transmitted by way of the bleed valve bellcrank to the bleed valve. This force moves the bleed valve in a spiral motion between an open or closed position, regulating LPC bleed air out the 2.5 bleed ducts in the Compressor Intermediate Case.

The LPC bleed air is discharged into the fan bypass airstream.



COMPRESSOR BLEED AIR SYSTEM – 2.5 BLEED VALVE LINKAGE

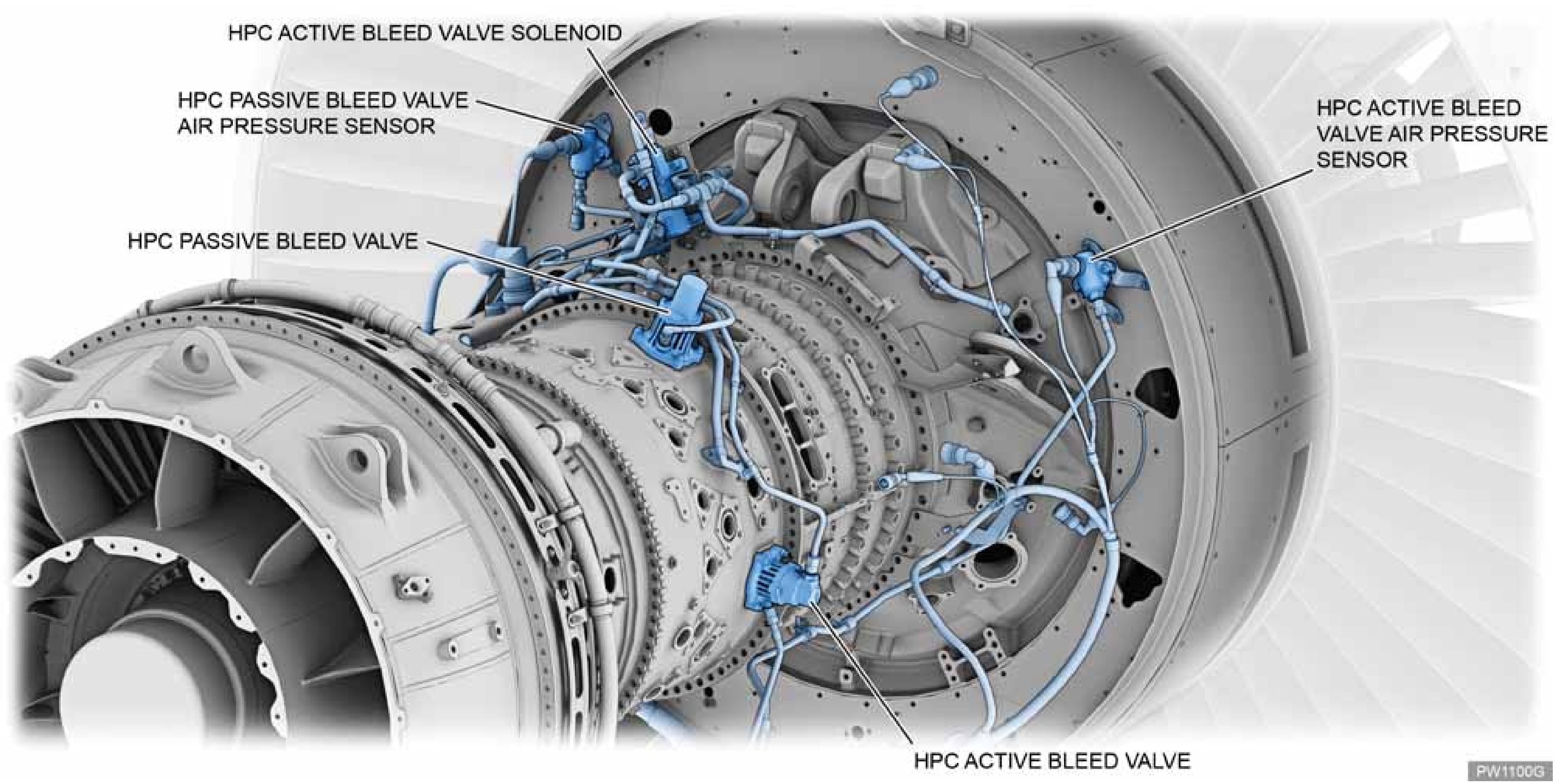
COMPRESSOR BLEED AIR SYSTEM (Cont.)

HPC Bleed Air System

The HPC Bleed Air System releases 6th Stage HPC air to improve engine startup performance.

The system has both active and passive components, as shown in the chart.

Component	Active	Passive
Bleed valve	✓	✓
Bleed valve air pressure sensor	✓	✓
Bleed valve solenoid	✓	



COMPRESSOR BLEED AIR SYSTEM – HPC BLEED AIR

COMPRESSOR BLEED AIR SYSTEM

HPC Bleed Air System (Cont.)

HPC Passive Bleed Valve

LRU PMT

Purpose:

The spring-loaded HPC passive bleed valve allows HPC 6th Stage air to bleed directly into the core compartment during engine start to help with initial compression of upstream core air flow.

Location:

The passive bleed air valve is located on the HPC case at 1:00.

Description:

The HPC passive bleed air valve is attached to the outer diffuser case boss by four bolts. A gasket is installed between the HPC bleed valve and the diffuser case to prevent air leakage.

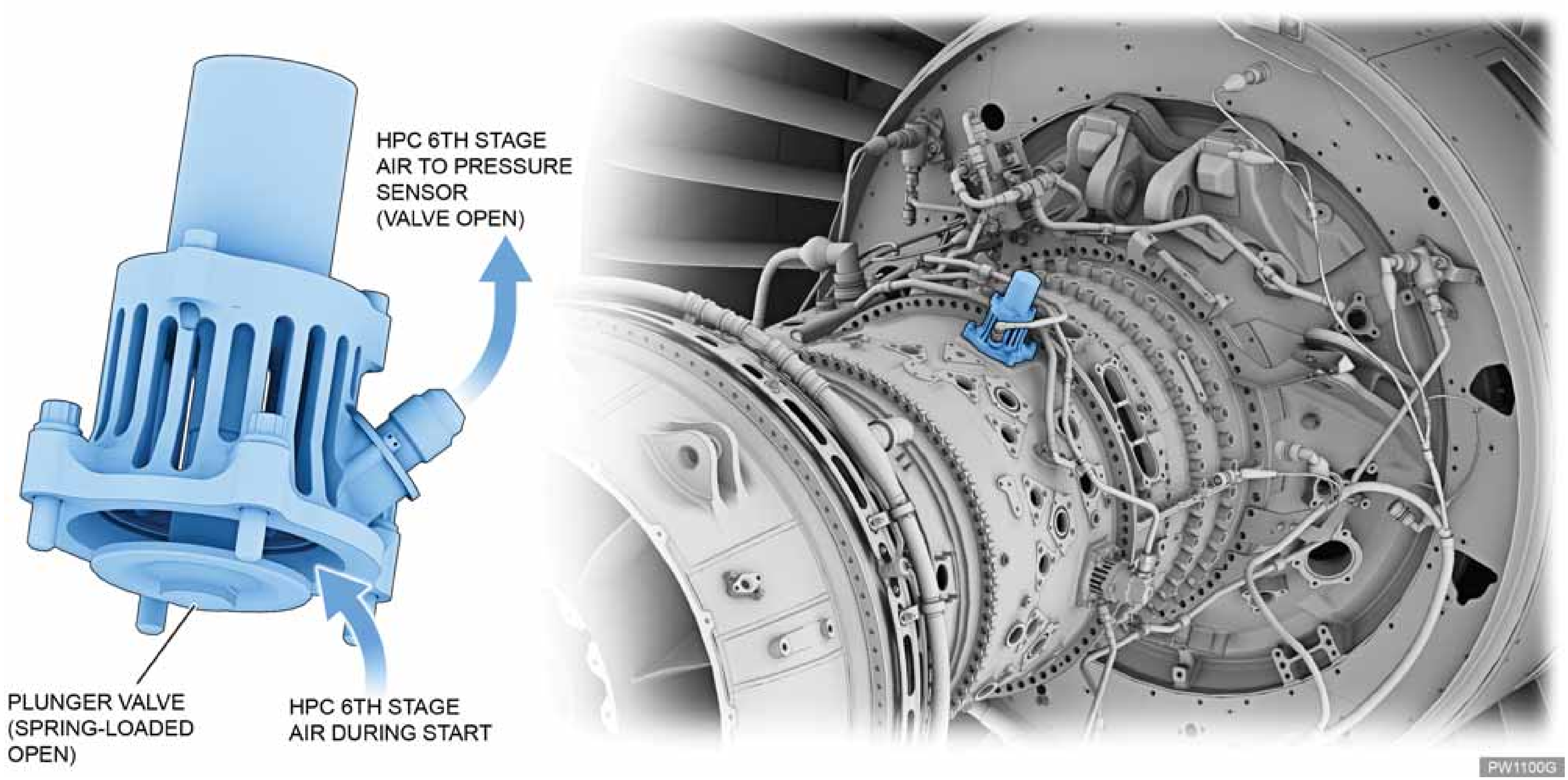
Safety Conditions

CAUTION

BEFORE YOU REMOVE THE VALVE FROM THE CASE, MAKE SURE THE AREA IS CLEAN AND FREE OF DEBRIS. THIS WILL PREVENT CONTAMINATION AND FOREIGN OBJECT DAMAGE TO THE ENGINE.

Operation:

The spring forces the bleed valve open when the pressure within the HPC is low. When sufficient pressure is developed in the HPC the valve is forced closed.



COMPRESSOR BLEED AIR SYSTEM – HPC PASSIVE BLEED VALVE

COMPRESSOR BLEED AIR SYSTEM

HPC Bleed Air System (Cont.)

HPC Active Bleed Valve

Purpose: LRU PMT

The spring-loaded HPC active bleed valve allows HPC 6th Stage air to bleed directly into the core compartment during engine start to help with initial compression of upstream core air flow.

Location:

The active bleed valve is located on the HPC case at 3:30.

Description:

The HPC active bleed valve is attached to the outer diffuser case boss by four bolts. A gasket is installed between the HPC active bleed valve and the diffuser case to prevent air leakage.

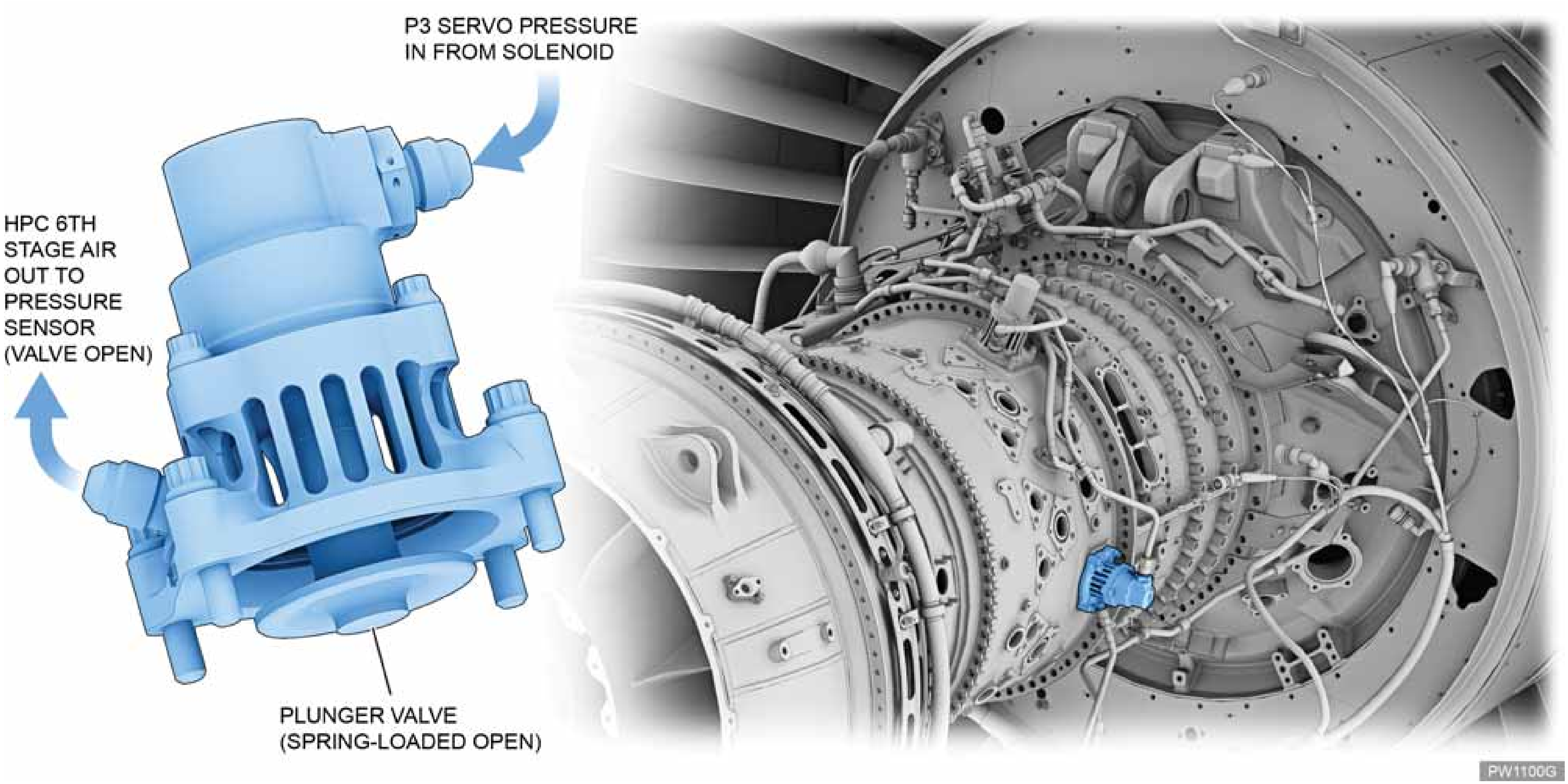
Operation:

The passive HPC bleed valve closes at sub-idle and the active HPC bleed valve is opened with Station 3 air supplied by the HPC active solenoid valve. At observed idle, the EEC will command the solenoid closed, shutting off P3 air. The active HPC bleed valve closes with Stage 6 HPC air.

Safety Conditions

CAUTION

BEFORE YOU REMOVE THE VALVE FROM THE CASE, MAKE SURE THE AREA IS CLEAN AND FREE OF DEBRIS. THIS WILL PREVENT CONTAMINATION AND FOREIGN OBJECT DAMAGE TO THE ENGINE.



COMPRESSOR BLEED AIR SYSTEM – HPC ACTIVE BLEED VALVE

COMPRESSOR BLEED AIR SYSTEM

HPC Bleed Air System (Cont.)

HPC Passive and Active Bleed Valve Air Pressure Sensors

Purpose:

LRU PMT

The dual-channel HPC active and passive bleed valve air pressure sensors measure the outlet air pressure on the HPC bleed valves.

Location:

Both sensors are located on the CIC. The passive sensor is located at approximately 10:00 and the active sensor is at approximately 2:00.

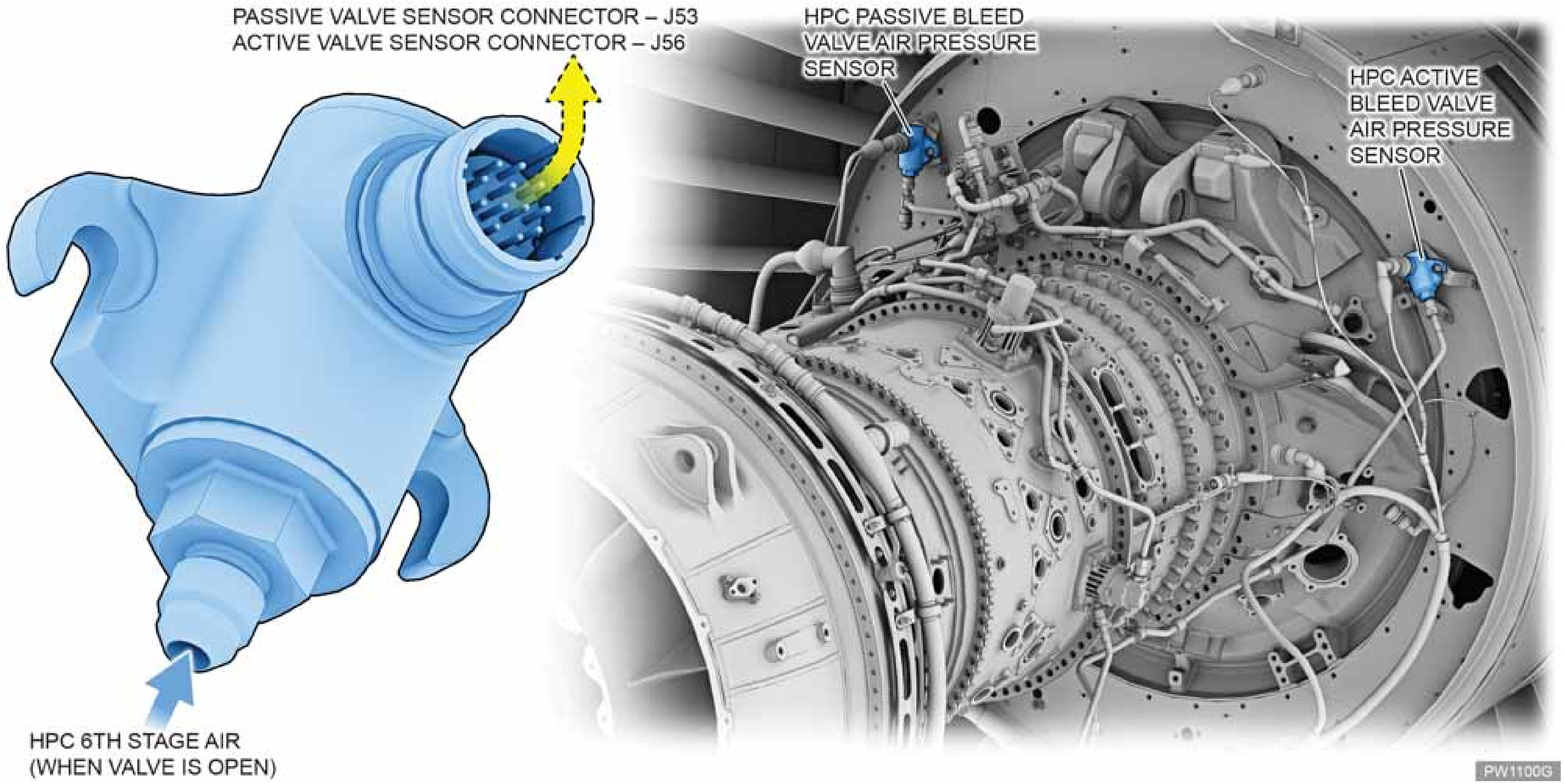
Description:

The pressure sensors consist of two independent, electrically isolated sensing elements, a stainless steel body, and an electrical connector. The components are assembled as a hermitically sealed unit. The stainless steel body has a mounting flange and houses the sensing elements.

Operation:

HPC bleed valve sense lines direct pressurized air from the HPC bleed valves to the HPC bleed valve pressure sensors' sensing elements. Each sensing element consists of a diaphragm with strain gages. When pressure is applied, the strain gages change resistance, which changes the output voltage.

This output voltage correlates directly to air pressure. Each sensing element is connected to the electrical connector and sends the air pressure signal to the EEC over separate channels.



COMPRESSOR BLEED AIR SYSTEM – HPC BLEED VALVE AIR PRESSURE SENSORS

COMPRESSOR BLEED AIR SYSTEM

HPC Bleed Air System (Cont.)

HPC Active Bleed Valve Solenoid

Purpose: LRU

The HPC active bleed valve solenoid provides discrete (on/off) control of P3 servo pressure sent to the HPC active bleed air valve.

Location:

The active bleed valve solenoid is located at 11:00 on the HPC case.

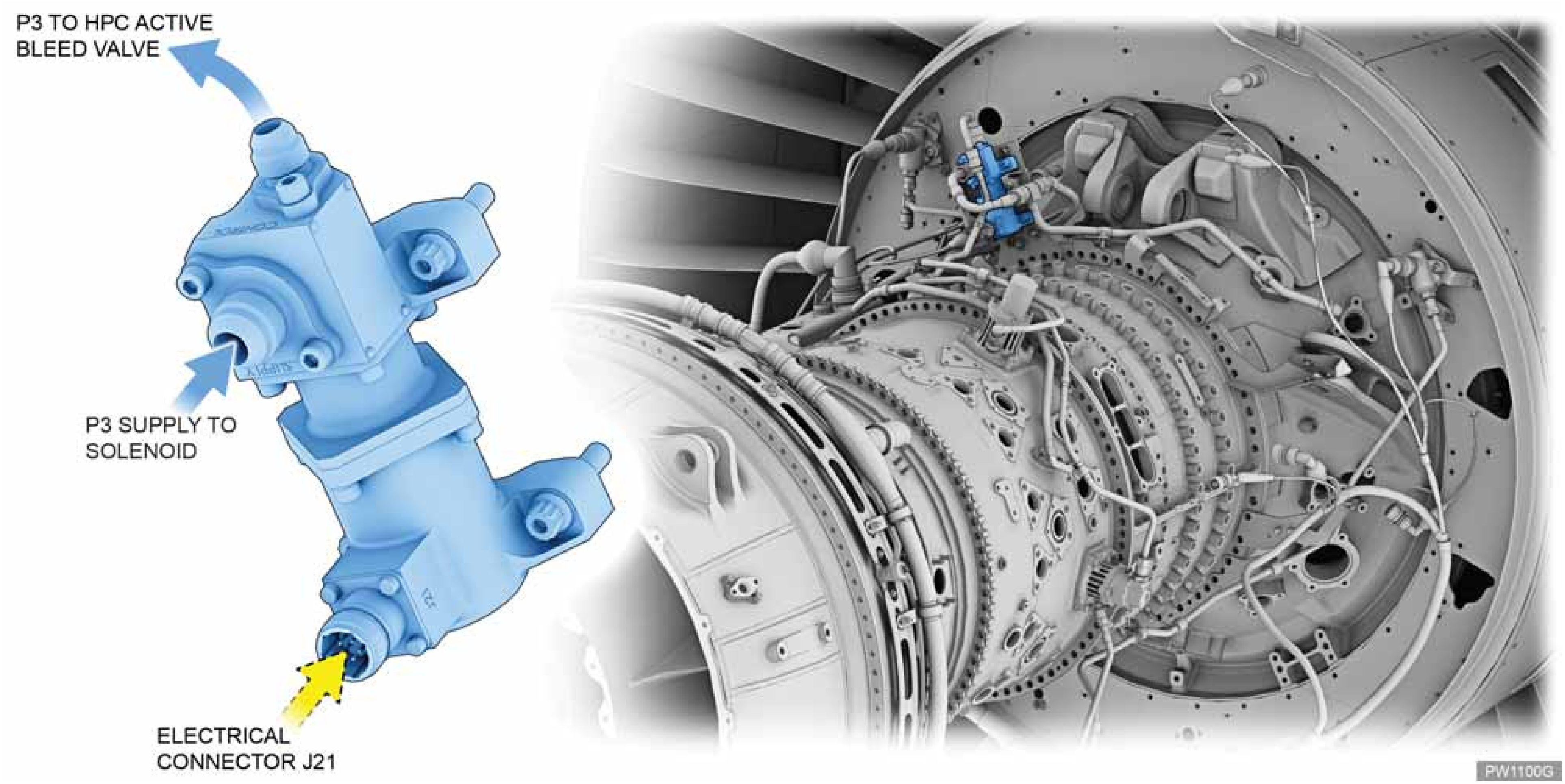
Description:

The dual-channel HPC active bleed valve solenoid controls the flow of P3 servo pressure to the HPC active bleed valve.

The active bleed valve solenoid is controlled by the EEC.

Operation:

When energized, the HPC active bleed valve solenoid allows the P3 servo pressure to flow to the HPC active bleed valve, forcing it to stay open.



COMPRESSOR BLEED AIR SYSTEM – HPC ACTIVE BLEED VALVE SOLENOID

COMPRESSOR BLEED AIR SYSTEM

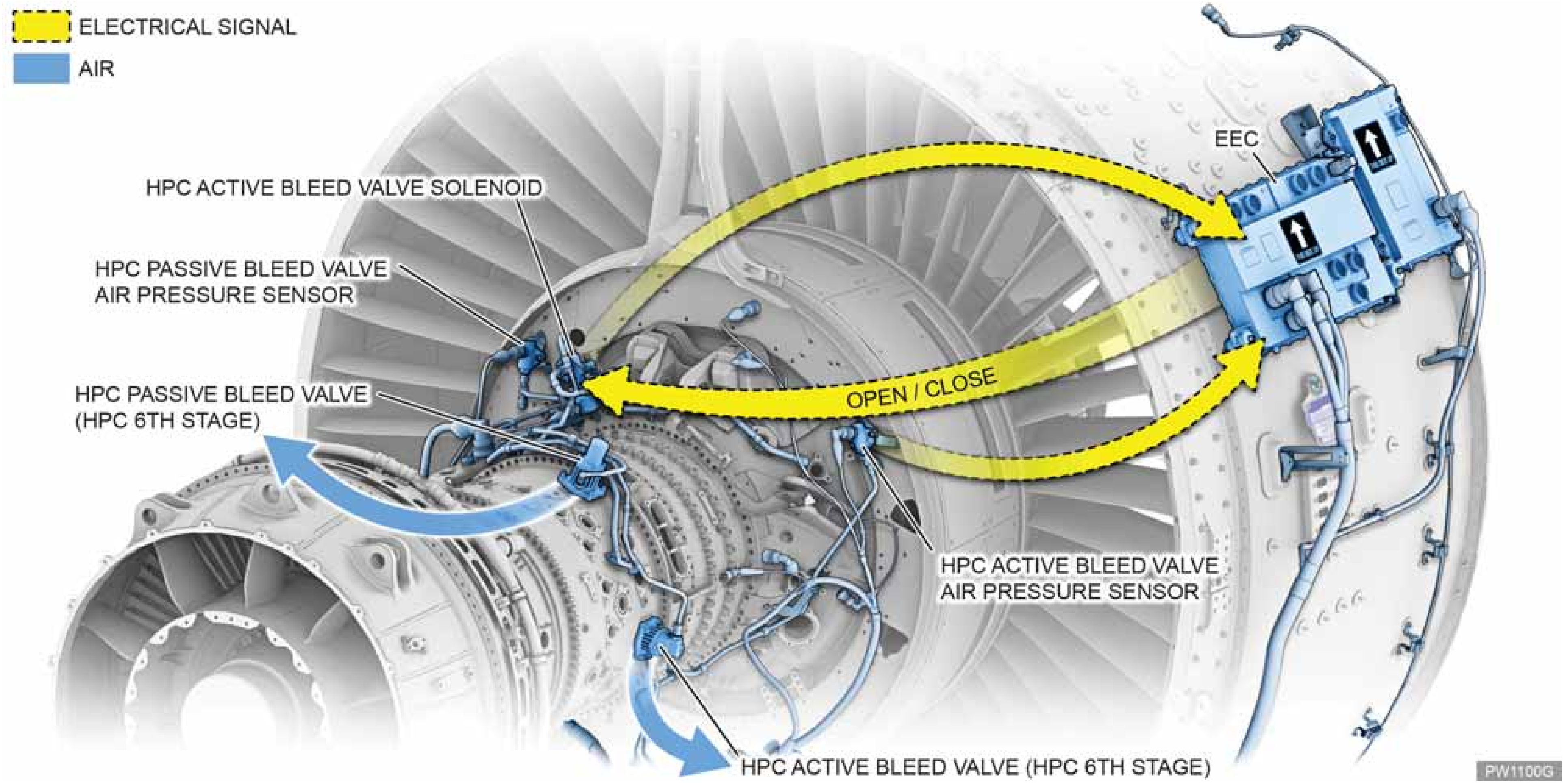
HPC Bleed Air System (Cont.)

Summary

The HPC active and passive bleed valves are mechanically spring-loaded open (fail safe) at start, which allows some of the 6th Stage HPC air to vent through the valves. Sense lines from the valves are connected to the HPC active and passive bleed valve pressure sensors. The sensors send an electronic signal to the EEC indicating valve position.

As N2 rotor speed increases, 6th Stage HPC pressure increases. When the pressure at the 6th Stage is high enough to overcome the spring load of the valve, the HPC passive bleed valve will be pushed closed. In sub-idle conditions, the valve will remain open to protect the engine from surge during starting.

The HPC active bleed valve operates by the same principle, except it is kept open for a longer duration during start, and it can be opened to avoid engine surge at various flight conditions. An EEC-controlled solenoid provides P3 air as pneumatic muscle (servo) pressure to keep the valve open as needed for engine performance.



COMPRESSOR BLEED AIR SYSTEM – HPC BLEED VALVE SYSTEM OPERATION FOR ENGINE START

TURBINE COOLING AIR (TCA) SYSTEM

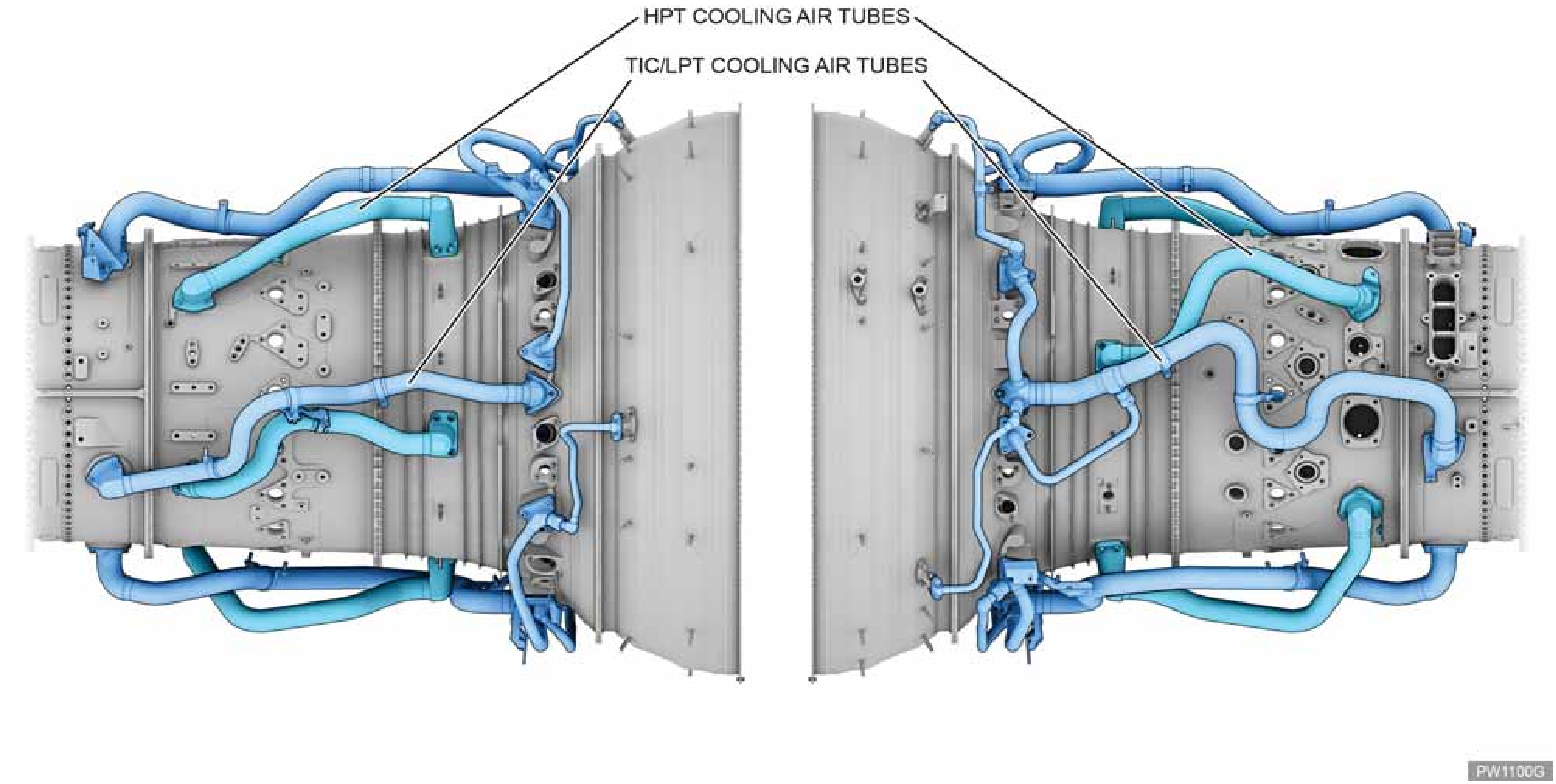
The Turbine Cooling Air System provides continuous cooling air to the High Pressure Turbine, and to the Turbine Intermediate Case/ Low Pressure Turbine.

Engine parts cooled by the system are shown below.

- High Pressure Turbine 2nd Stage vanes between the 1st and 2nd stage rotors
- HPT 2nd Stage blade attachment
- Turbine Intermediate Case (TIC) fairings
- LPT case
- LPT rotor and blade attachments

Jumper air and cooling air tubes for each component are shown in the chart.

<table>
<tr><th>Component</th><th>Jumper Air Tubes</th><th>Cooling Air Tubes</th></tr>
<tr><td>HPT</td><td>N/A</td><td rowspan="3">4</td></tr>
<tr><td>TIC</td><td rowspan="2">8</td></tr>
<tr><td>LPT rotor</td></tr>
<tr><td>LPT case</td><td>3</td><td>N/A</td></tr>
</table>



TURBINE COOLING AIR (TCA) SYSTEM

TURBINE COOLING AIR (TCA) SYSTEM (Cont.)

High Pressure Turbine Cooling Air Tubes

Purpose:

HPT cooling air provides continuous airflow of 6th Stage bleed air to the HPT 2nd Stage vanes.

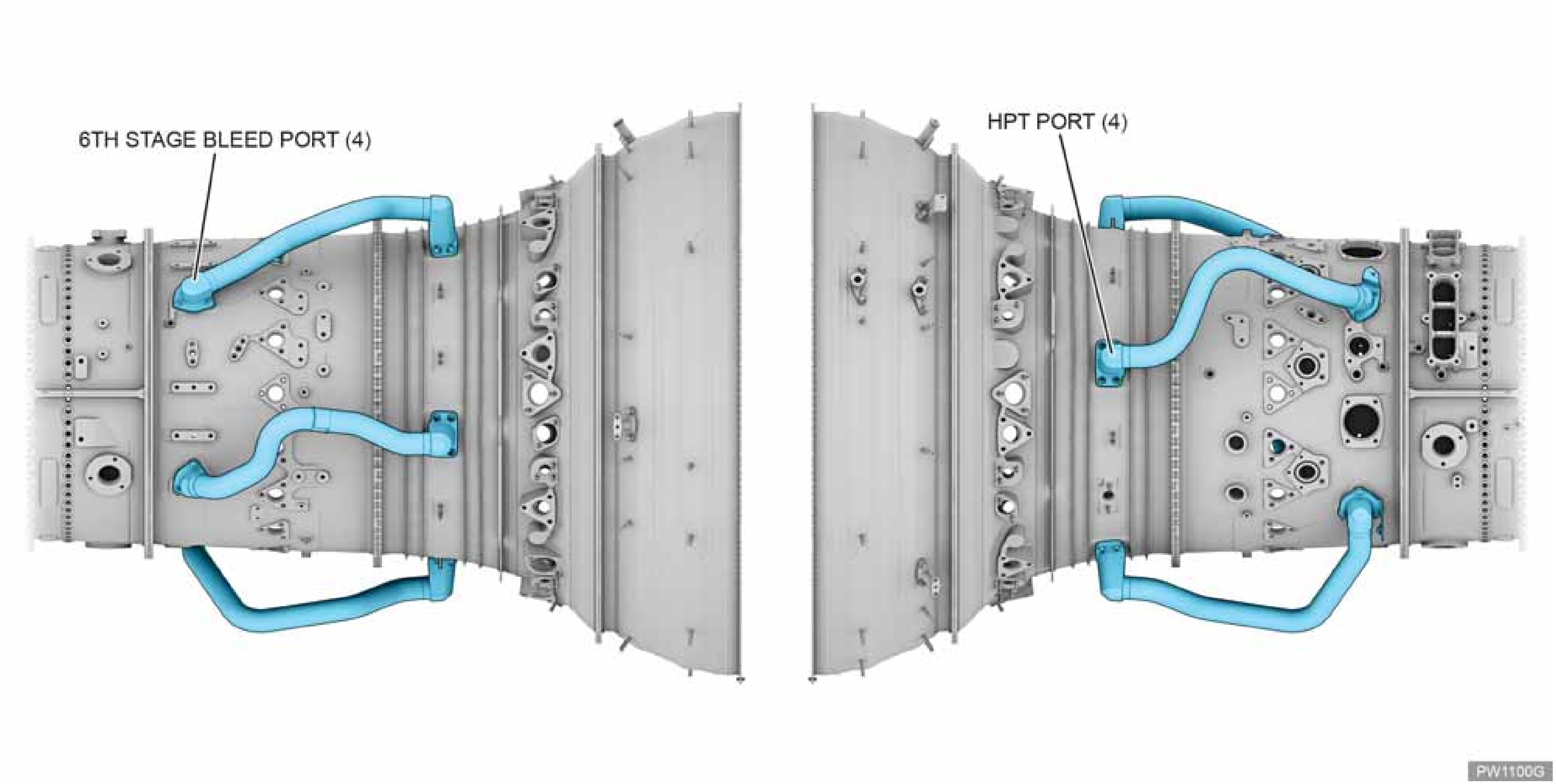
Location:

The airflow tubes are located approximately 90° apart at these positions: 1:00, 5:00, 7:00, 10:00.

Description:

The system consists of four TCA tubes that provide cooling airflows into the hollow vanes, and through passages that exit out of the trailing edges of vanes and vane platforms.

The air is metered by plates located between the HPT case and tubes.



TURBINE COOLING AIR SYSTEM – HPT COOLING AIR TUBES (HPT 6th STAGE AIR)

TURBINE COOLING AIR (TCA) SYSTEM (Cont.)

Turbine Intermediate Case/
Low Pressure Turbine Cooling Air Tubes

Purpose:

PMT

TIC/LPT cooling air tubes provide continuous flow of HPC 3rd Stage bleed air to the Turbine Intermediate Case and LPT case and rotor.

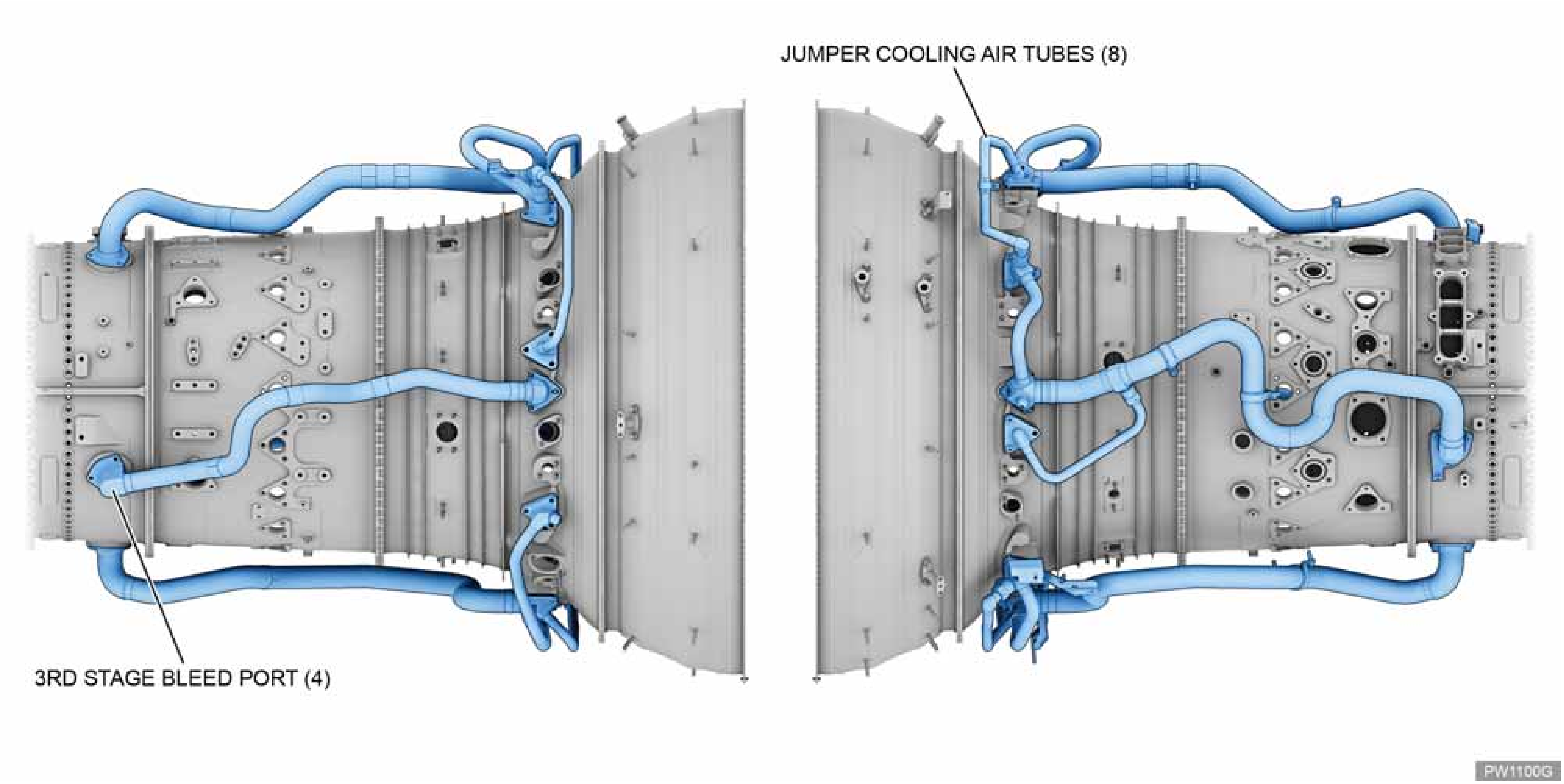
Location:

Four TIC cooling air tubes are positioned at 3:30, 6:00, 8:00 and 11:00. Eight jumper tubes are installed around the radius of the TIC fairing and three more are located on the LPT case at 12:00, 4:30 and 9:00.

Description:

The four TIC cooling air tubes cool the TIC fairings, as well as the inner and outer TIC walls known as transition ducts.

The eight jumper tubes that feed off the four cooling tubes send air through the TIC connecting rods to the LPT rotors and blade attachments.



TURBINE COOLING AIR SYSTEM – TIC/LPT COOLING AIR TUBES (HPC 3rd STAGE AIR)

TURBINE COOLING AIR (TCA) SYSTEM (Cont.)

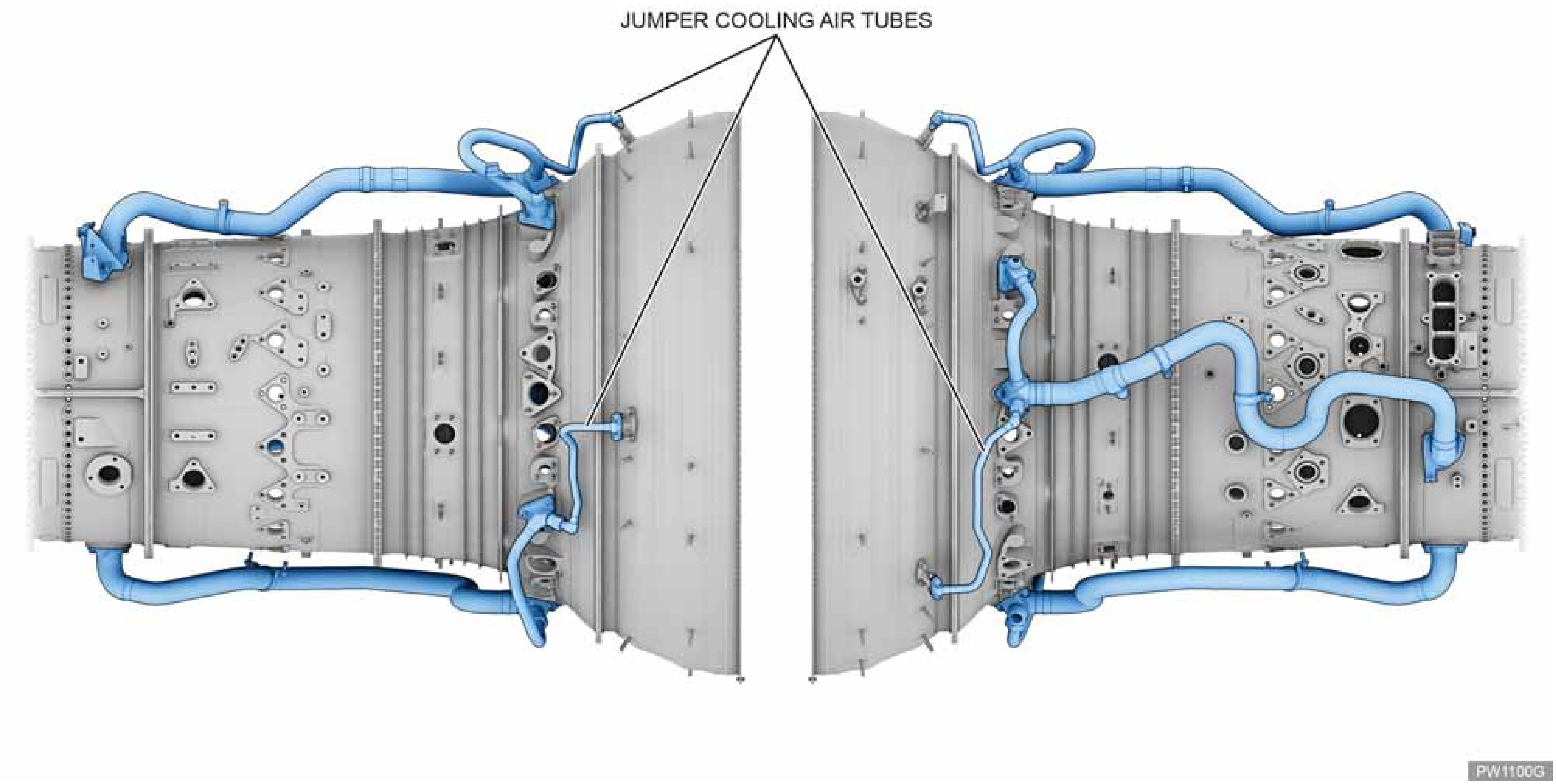
Low Pressure Turbine Cooling Air Tubes

Purpose:

The LPT cooling air tubes are jumper tubes that direct cooling air between the LPT outer case and 2nd Stage vanes.

Location:

The three jumper tubes are located on the LPT case at 12:00, 4:30 and 9:00.



TURBINE COOLING AIR SYSTEM – LPT COOLING AIR TUBES (HPC 3rd STAGE AIR)

ENGINE BEARING COOLING SYSTEM

The Engine Bearing Cooling System provides sealing air to the engine main bearing compartments. It also supplies cooling air to prevent oil leakage, and provides air to the inlet cone for anti-ice operations. Components are listed below.

- Buffer Air Valve BAV
- Buffer Air Valve solenoid
- Buffer Air Check Valve BACV
- Buffer Air Pressure Sensor BAPS
- Buffer Air Heat Exchanger BAHE
- Buffer Air Manifold BAM
- External cooling tubes

Bearing compartments are cooled using a split buffer bearing cooling system, which supplies the compartments with cooling and sealing air from different sources based on engine pressure requirements.

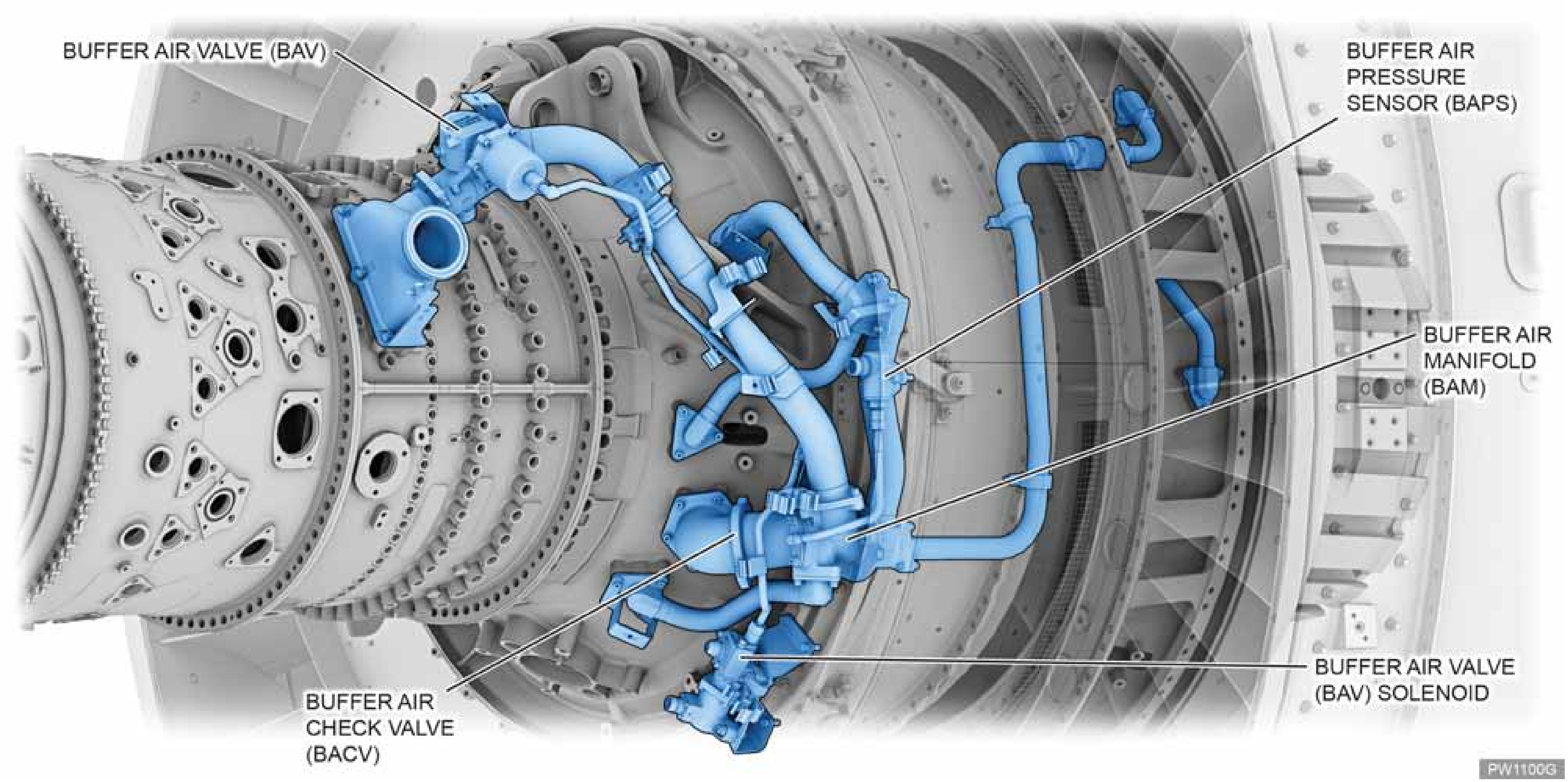
HPC 3rd Stage air flows continuously through the buffer air valve to the Buffer Air Heat Exchanger, where it is cooled and then routed through external and internal tubes to the No. 4 Bearing compartment.

The EEC controls buffer air to the three compartments that house bearing nos. 1, 1.5, 2, 3, 5, and 6. The compartments are cooled and sealed using 4^{th} Stage HPC air at low power and Station 2.5 bleed air at high power.

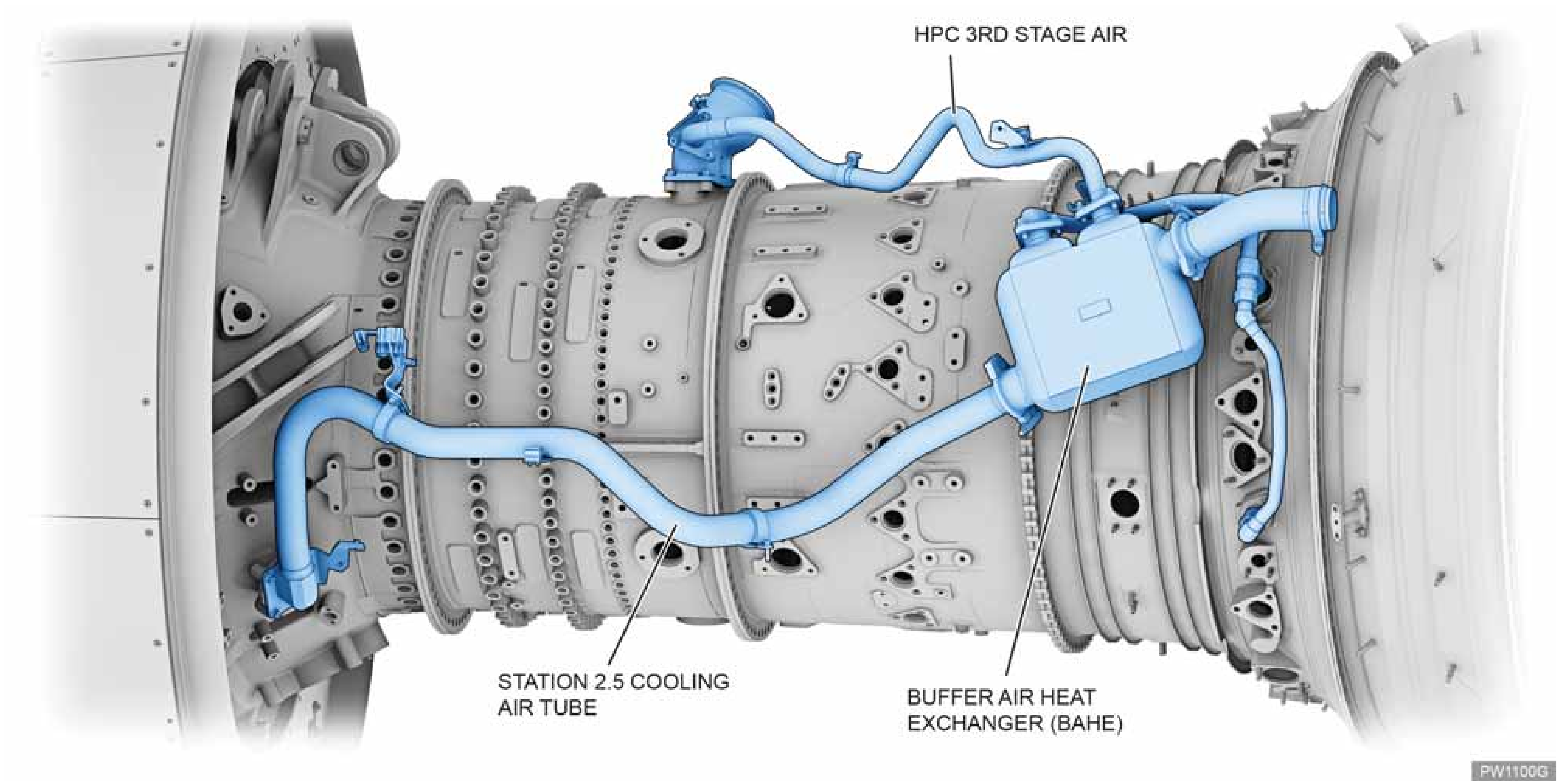
The system controls the flow of HPC Stage 3 air to maintain the proper air pressure at bearing compartment nos. 1, 2, 3, and 5/6, ensuring proper functioning of the carbon seals.

At high power settings, pressurized air is provided from LPC exit stage 2.5 bleed air.

At low engine power settings, pressurized air is provided from the HPC 3^{rd} Stage.



ENGINE BEARING COOLING SYSTEM – RIGHT SIDE



ENGINE BEARING COOLING SYSTEM – LEFT SIDE

ENGINE BEARING COOLING SYSTEM (Cont.)

Buffer Air Valve (BAV)

Purpose: LRU

The Buffer Air Valve provides discrete (on/off) control of HPC 3rd Stage bleed air supply to the Bearing Ventilation System.

Location:

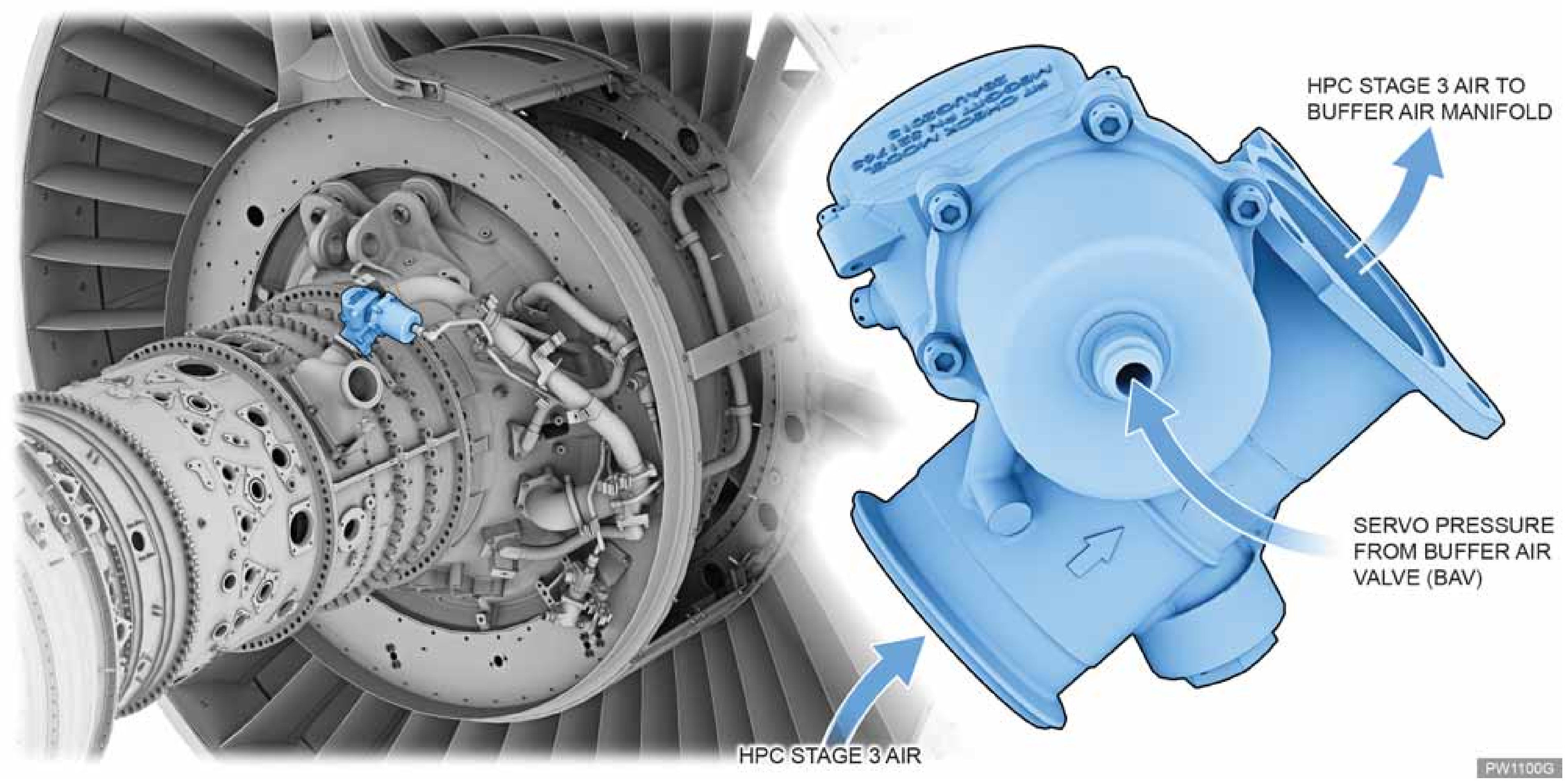
The valve is located on the HPC split case at 1:00.

Description:

Bearing compartments that house bearing nos. 1, 1.5, 2, 3, and 5/6 are cooled using the EEC-controlled Buffer Air Valve. The BAV consists of an actuator cover and housing that contains a spring and piston assembly. The valve is spring-loaded closed. It is actuated by HPC 8th Stage servo pressure that is controlled by the Buffer Air Valve solenoid.

Operation:

When HPC 8th Stage servo pressure is applied, it pushes the spring-loaded piston forward. In the actuator housing, the piston is connected to a shaft through an internal linkage that rotates the shaft when the piston moves forward or aft. A butterfly valve in the valve body is connected to the shaft, allowing it to open or close based on the piston position.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR VALVE (BAV)

ENGINE BEARING COOLING SYSTEM (Cont.)

Buffer Air Valve (BAV) Solenoid

Purpose: LRU

The Buffer Air Valve solenoid provides discrete (on/off) control of the P3 servo pressure sent to the Buffer Air Valve.

Location:

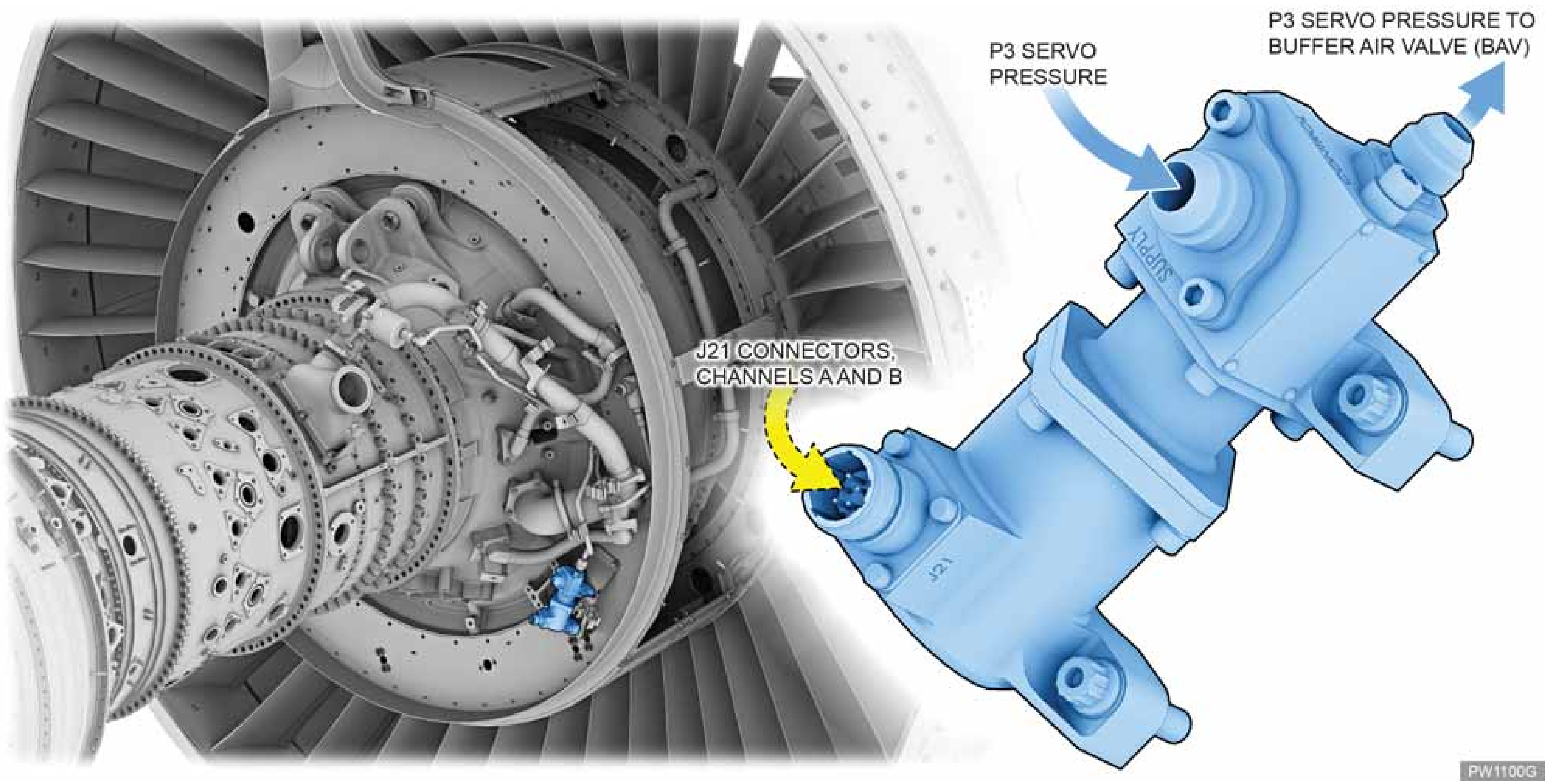
The solenoid is located on the CIC firewall at 5:00.

Description:

The dual-channel solenoid is controlled by the EEC.

Operation:

When the solenoid is de-energized, the Buffer Air Valve is closed, shutting off the flow of P3 servo pressure. When the solenoid is energized, the valve is open, allowing P3 servo pressure to flow to the BAV. P3 servo pressure lines direct air from P3 pressure to the shutoff valve solenoid, and from the solenoid to the BAV.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR VALVE SOLENOID

ENGINE BEARING COOLING SYSTEM (Cont.)

Buffer Air Check Valve (BACV)

Purpose: LRU PMT

The Buffer Air Check Valve (BACV) prevents HPC 3rd Stage air from flowing into the LPC flow path while being used by the Bearing Ventilation System.

Location:

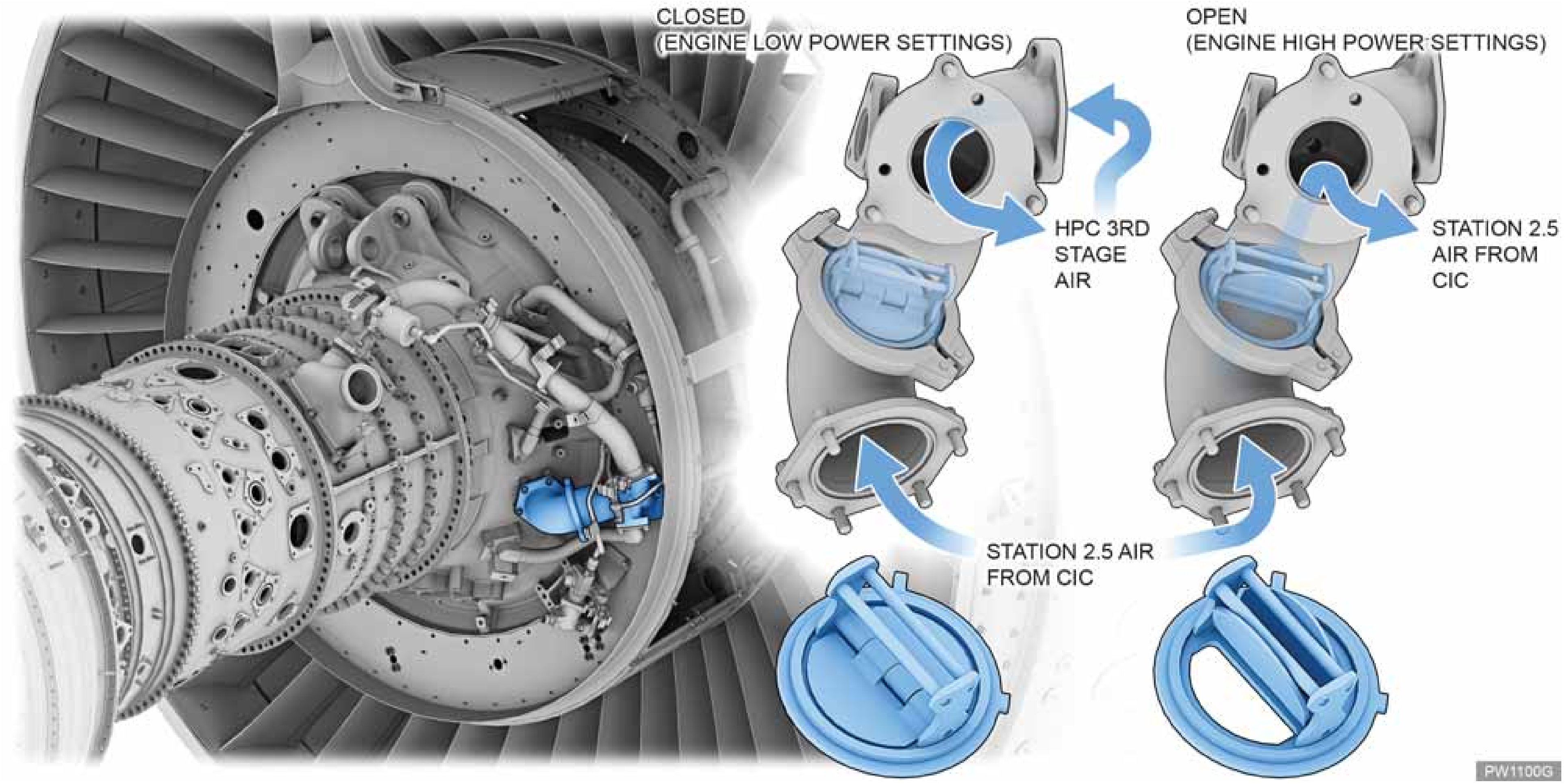
Located inside the Buffer Air Manifold (BAM) at 4:30, the check valve is not visible.

Description:

The check valve is a passive device with two flappers that hang from the flapper shaft in the open position at engine start.

Operation:

LPC buffer air flows past the valve at low power settings. When the EEC commands the Buffer Air Valve to open, the HPC 3rd Stage air forces the flappers to close, preventing backflow into the LPC. The flappers pivot on the flapper shaft due to air pressure.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR CHECK VALVE (BACV) POSITIONS

ENGINE BEARING COOLING SYSTEM (Cont.)

Buffer Air Pressure Sensor (BAPS)

Purpose: LRU PMT

The Buffer Air Pressure Sensor provides feedback to the EEC to validate the position of the Buffer Air Valve (BAV).

Location:

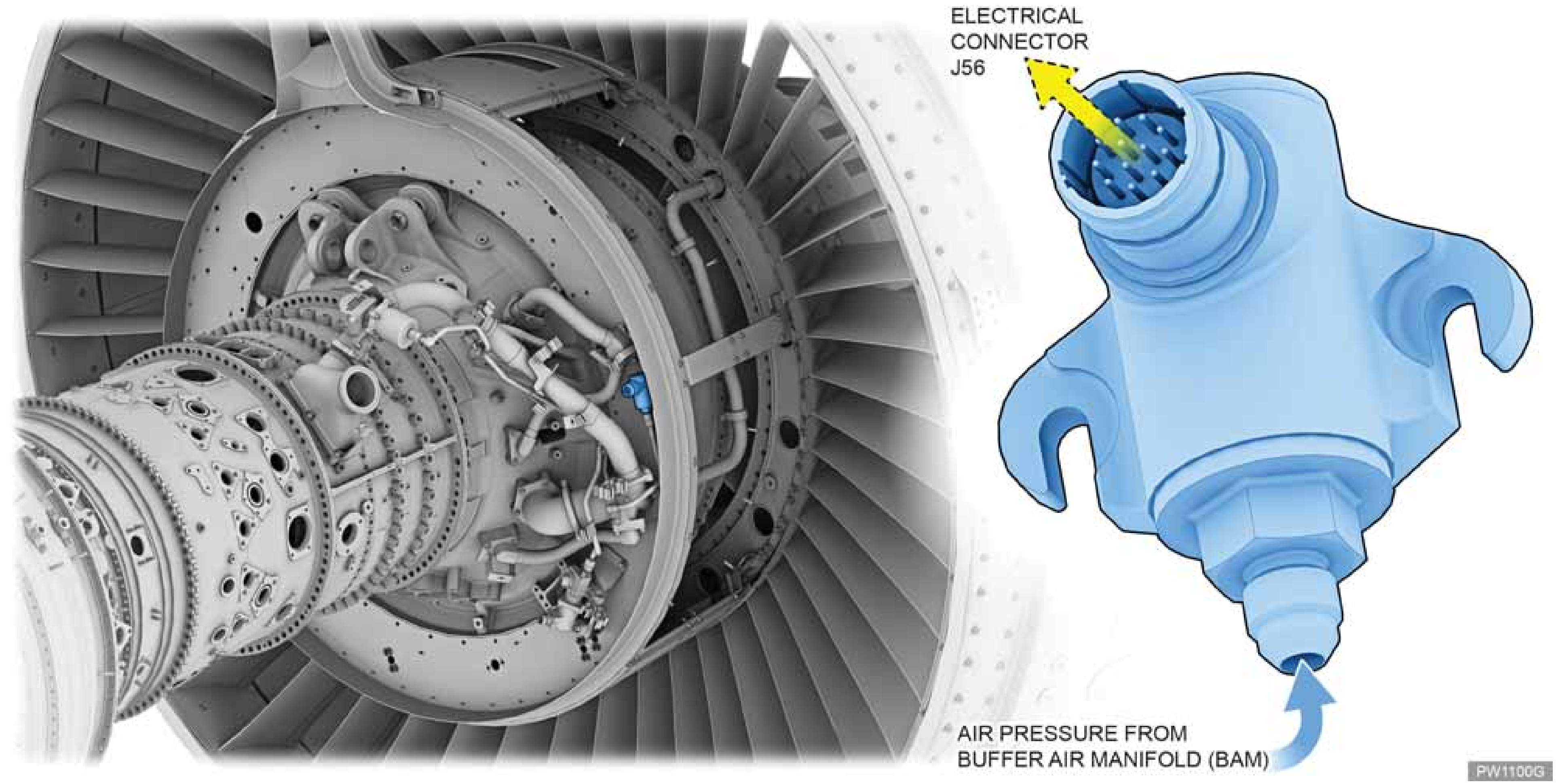
The dual-channel BAPS is located downstream of the Buffer Air Manifold on the Compressor Intermediate Case at 3:00.

Description:

The signal provided to the EEC confirms the position (open or closed) of the Buffer Air Check Valve (BACV) and the BAV.

Operation:

Buffer air pressure downstream of the BAV flows to the sensor via a sense line. The sense line is connected to a manifold that is mounted to the CIC fire seal. The sensor converts the pneumatic pressure signal to a digital signal, supplied to the EEC through a harness. The EEC can determine BAV position by the pressure of the air flowing into the manifold.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR PRESSURE SENSOR (BAPS)

ENGINE BEARING COOLING SYSTEM (Cont.)

Buffer Air Heat Exchanger (BAHE)

Purpose: LRU PMT✓

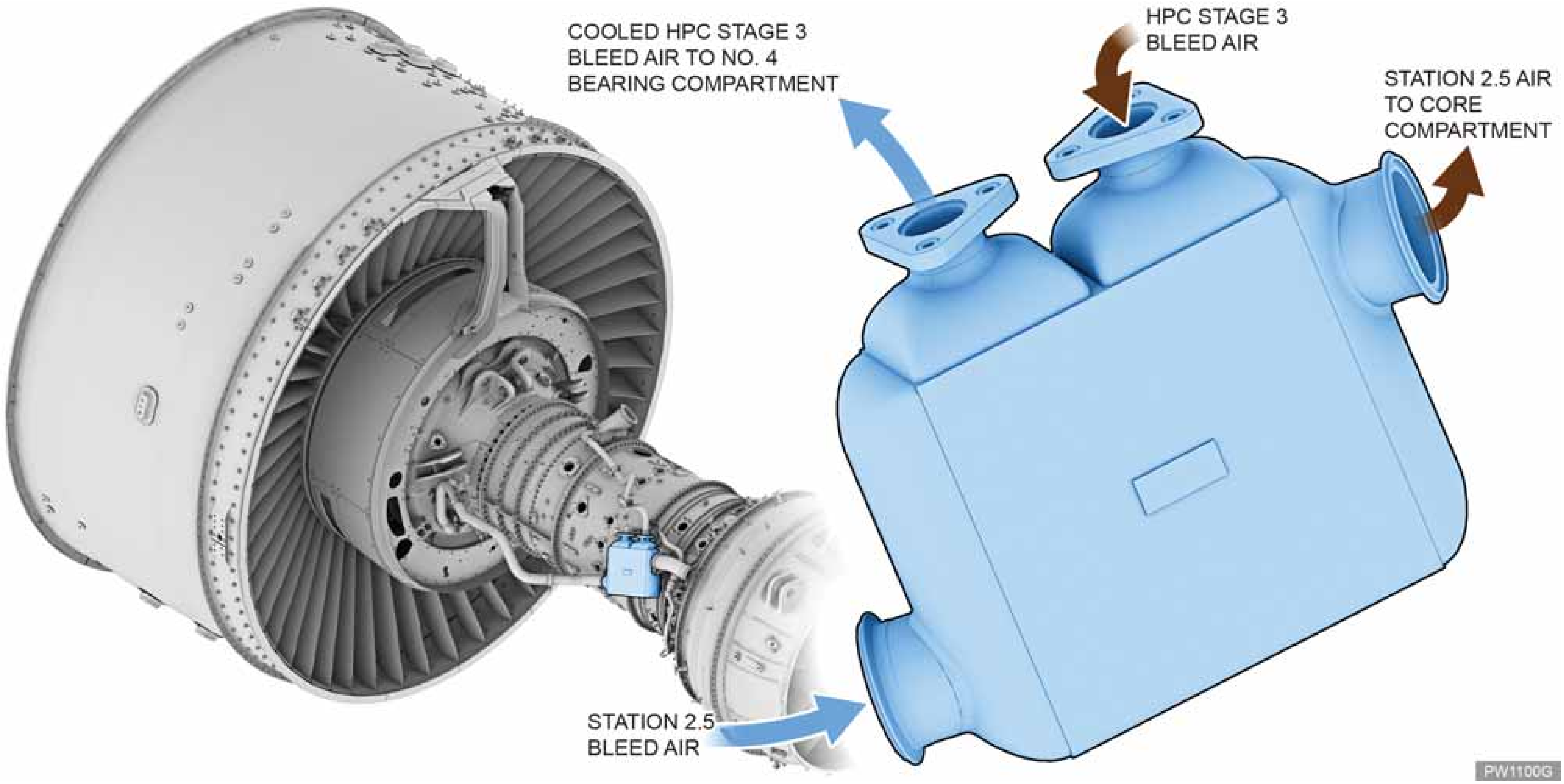
The Buffer Air Heat Exchanger uses Station 2.5 bleed air to cool HPC 3rd Stage air before its delivery to the No. 4 Bearing housing.

Location:

The BAHE is attached to the diffuser case at 11:00.

Description:

The Buffer Air Heat Exchanger is a sealed assembly mounted on brackets. The assembly contains a tube matrix consisting of a number of U-shaped tubes brazed into a tube plate. The tubes are held in place by stainless steel baffles.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR HEAT EXCHANGER OPERATION

ENGINE BEARING COOLING SYSTEM

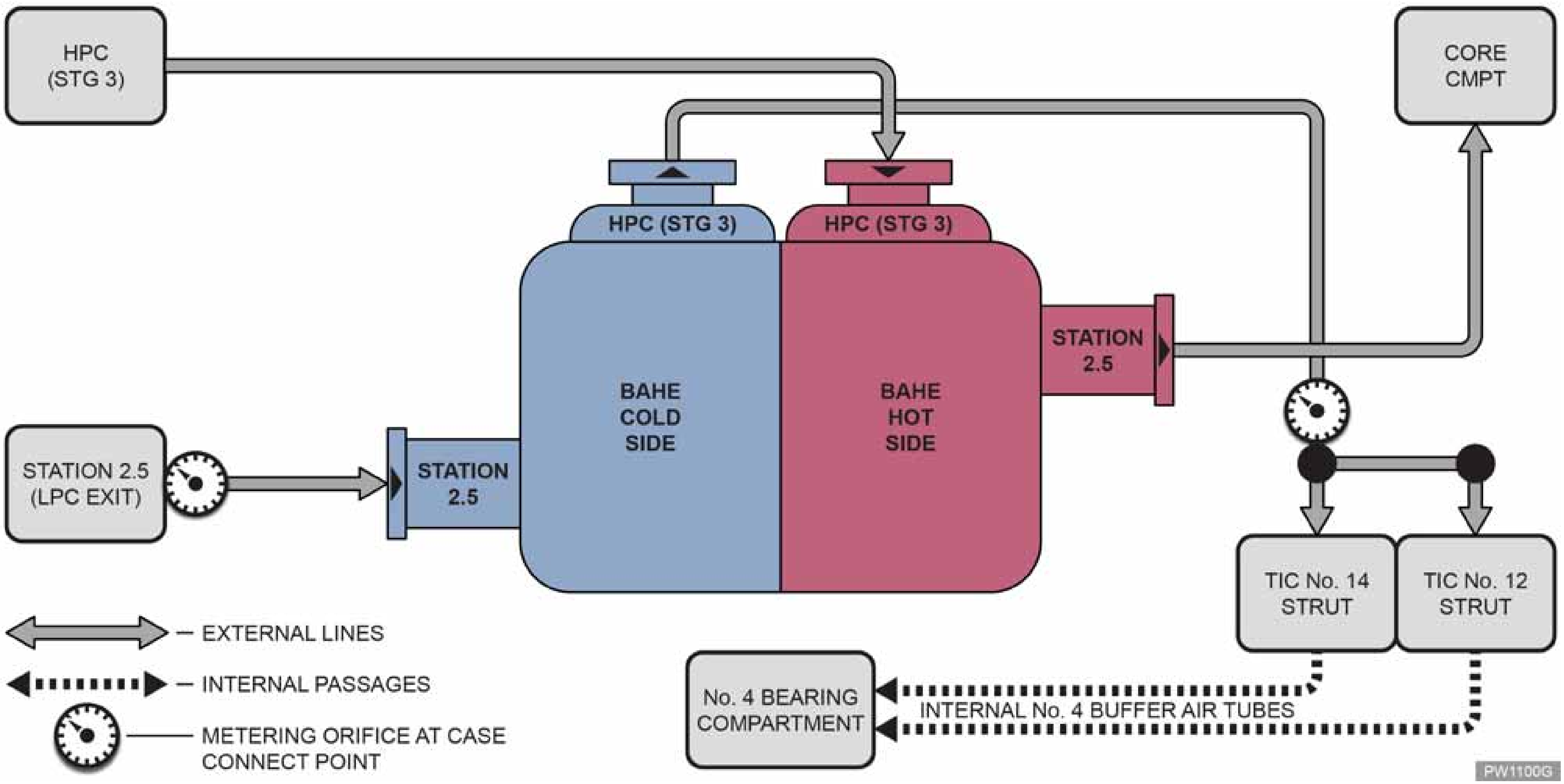
Buffer Air Heat Exchanger (BAHE) (Cont.)

Operation:

1. Station 2.5 bleed enters the Buffer Air Heat Exchanger to cool the 3rd Stage HPC air.

2. Station 2.5 bleed air exits the BAHE and discharges overboard.

3. 3rd Stage HPC air enters BAHE and flows through the tube matrix and then enters the No. 4 Bearing compartment for cooling.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR HEAT EXCHANGER OPERATION

ENGINE BEARING COOLING SYSTEM

Buffer Air Manifold (BAM)

Purpose: LRU

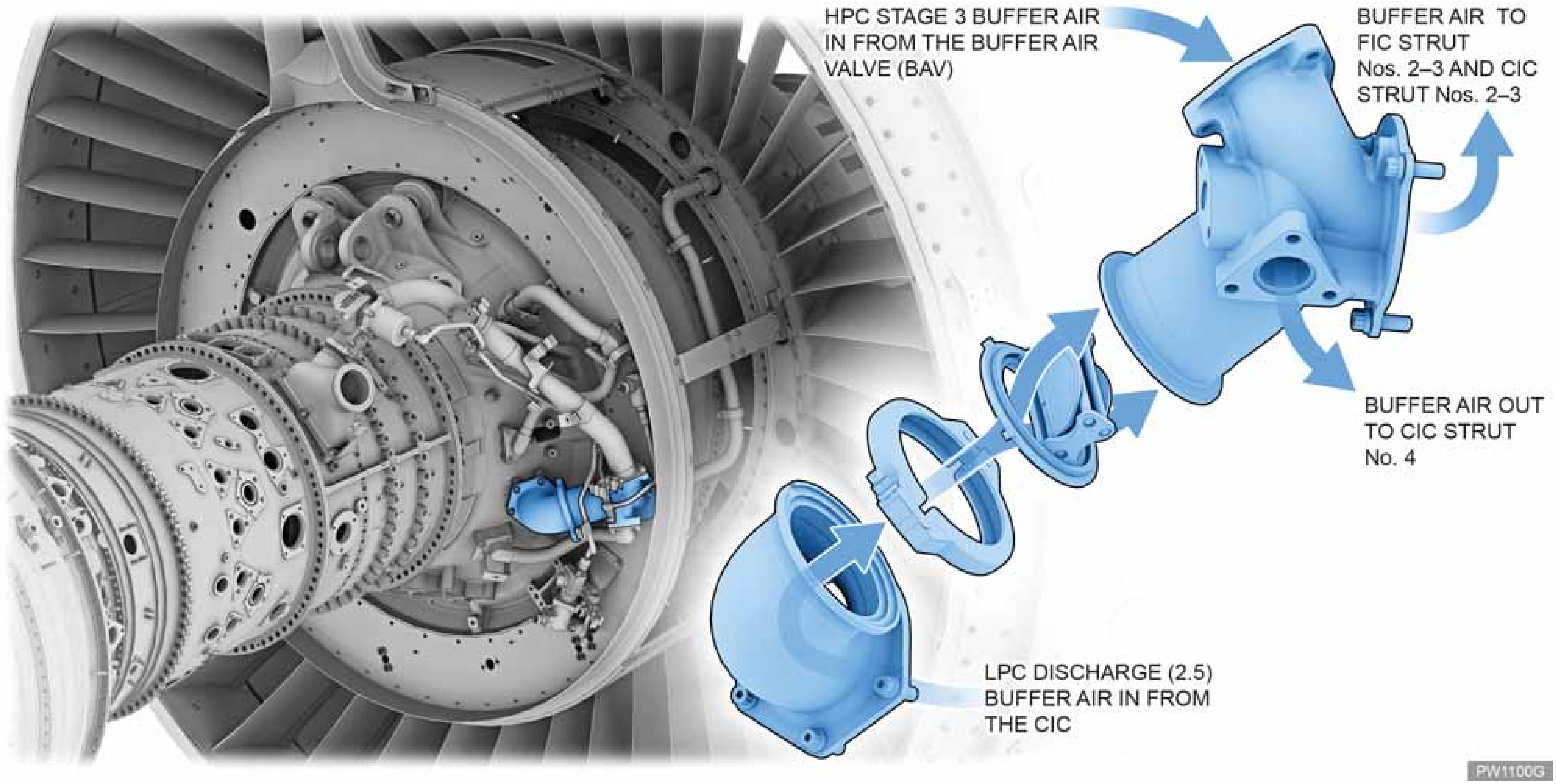
The Buffer Air Manifold directs buffer air to the Bearing Ventilation System, including bearing compartment nos. 1, 2, 3, and 5/6.

Location:

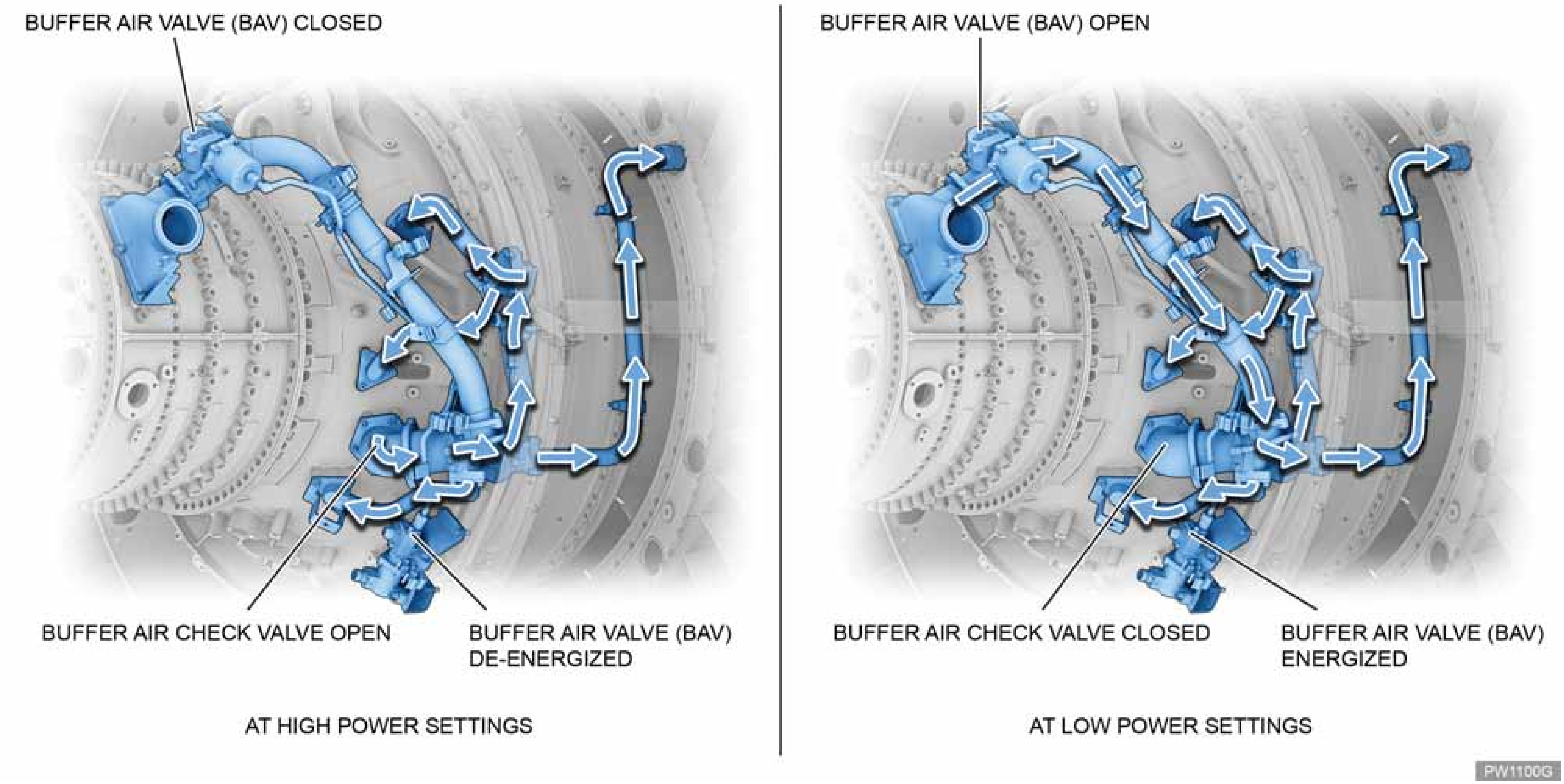
The BAM is attached to the Compressor Intermediate Case at 4:00.

Description:

The BAM receives air directly from the LPC and from the 3rd Stage HPC from tubes attached to the Buffer Air Valve and the CIC.



ENGINE BEARING COOLING SYSTEM – BUFFER AIR MANIFOLD



ENGINE BEARING COOLING SYSTEM AIRFLOW

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM

The Active Clearance Control System meters fan cooling air that is ducted from the nacelle thrust reverser door and sent to the turbine cases. The cooling air limits turbine case growth during thermal expansion, reducing HPT and LPT blade tip clearance and improving fuel efficiency over the whole operating range.

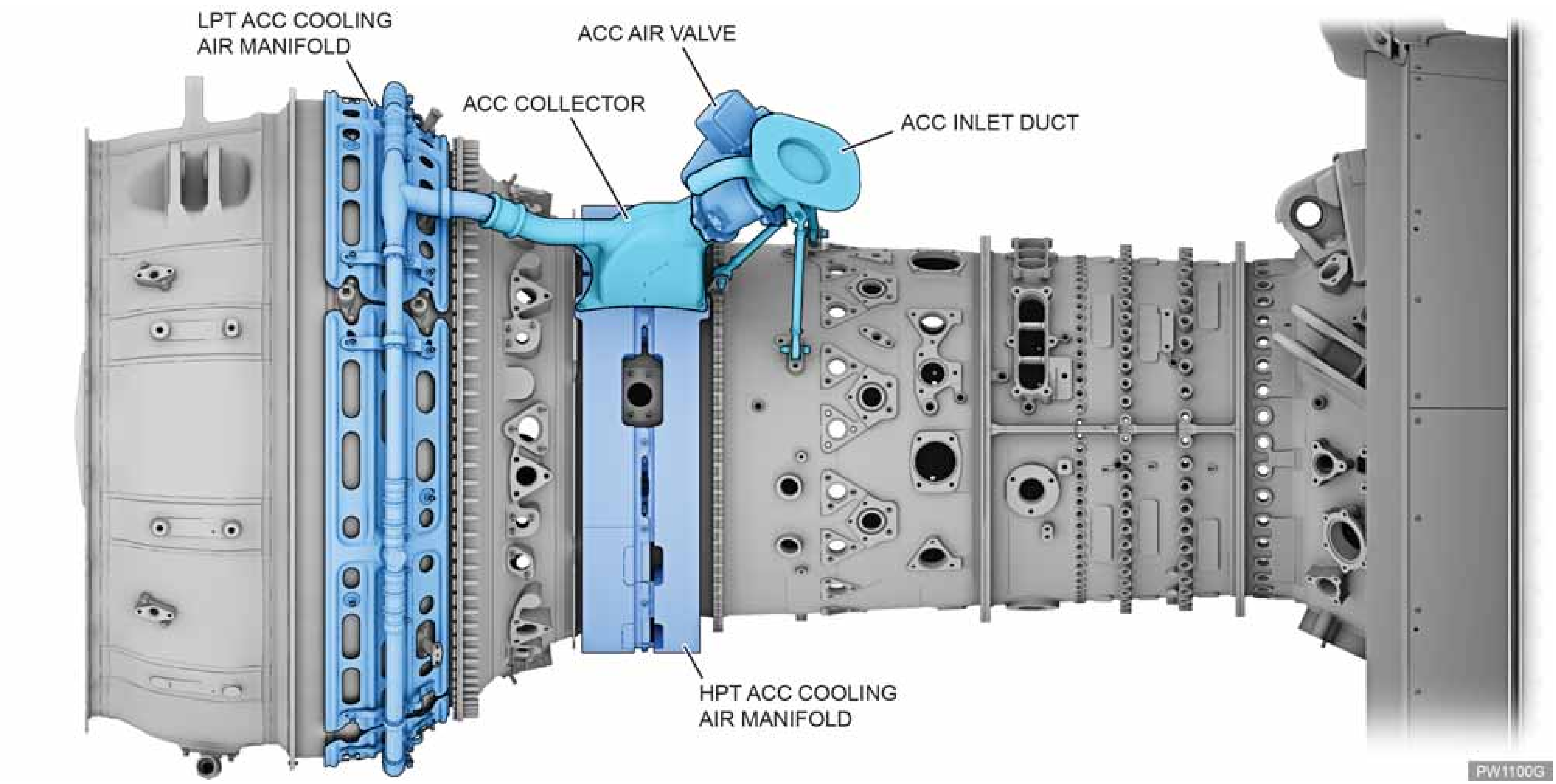
The ACC System includes the components shown below.

- ACC inlet duct
- ACC air valve and actuator
- ACC collector
- ACC cooling manifolds for HPT and LPT
- ACC air distribution tube assembly (LPT)

System schedules are based on engine parameters and altitude.

KEY FACT

Fan bypass air cools and controls expansion of the turbine case to match the radial expansion of the rotor.



TURBINE ACTIVE CLEARANCE CONTROL (ACC) SYSTEM

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM (Cont.)

Inlet Duct

Purpose:

LRU

The inlet duct receives and directs fan bypass cooling air to the ACC valve and actuator.

Location:

The inlet duct is located on the diffuser case at 1:00.

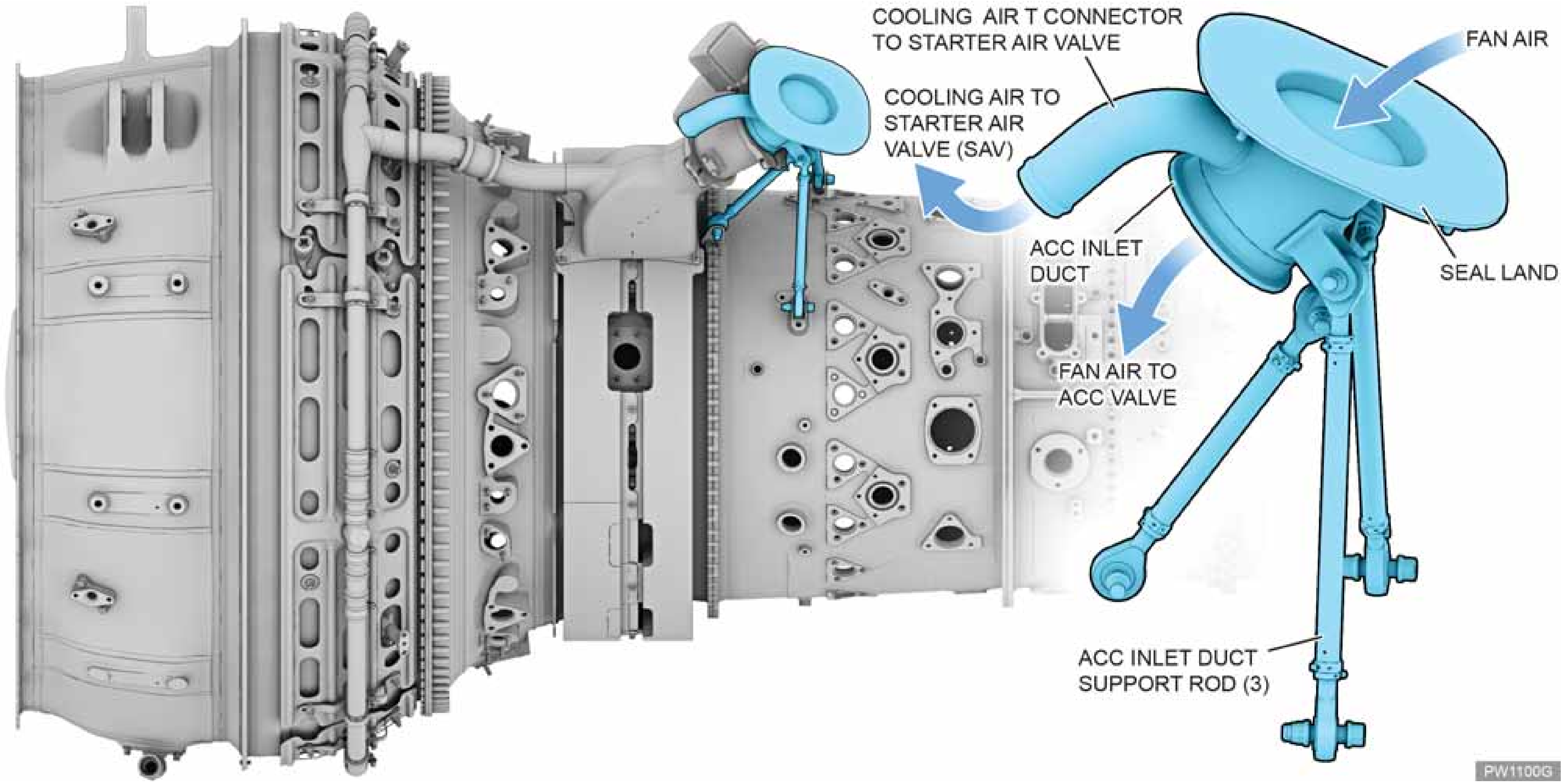
Description:

The inlet duct is made of stainless steel. To prevent cooling air leakage, the outboard side of the duct has a seal land that contacts a bellow seal attached to the nacelle door. The inboard end of the duct is attached with a clamp to the ACC valve and actuator.

Three support rods bolted to three brackets provide axial support for the inlet duct. The rods are bolted to the diffuser case at the inboard end and to the inlet duct at the outboard end.

Operation:

Fan bypass air enters the inlet duct via the Inner Fixed Structure of the nacelle.



ACTIVE CLEARANCE CONTROL SYSTEM – ACC INLET DUCT

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM (Cont.)

ACC Air Valve and Actuator

Purpose:

LRU PMT

The ACC air valve is a fuel-actuated butterfly valve that regulates the flow of cooling air to the turbine cases.

Location:

The air valve and actuator are located on the diffuser case at 1:00.

Description:

The dual-channel valve and actuator are controlled by the EEC based on N2 speed and altitude. A fuel-actuated piston opens and closes the butterfly valve. The piston is attached via a link to the butterfly valve shaft. The valve is held in position relative to the shaft by a tapered pin that goes through a hole in the center shaft.

The valve and actuator are attached to the ACC collector with a clamp and a seal that prevent leakage between the components.

A single-channel Linear Variable Differential Transformer (LVDT) is mechanically coupled to the actuator piston to provide an electrical feedback signal to Channel A of the EEC.

Safety Conditions

CAUTION

DO NOT BEND THE FUEL TUBES WHEN YOU DISCONNECT THEM FROM THE VALVE. DAMAGE TO THE FUEL TUBES WILL OCCUR IF TOO MUCH FORCE IS APPLIED TO THE TUBES.

Operation:

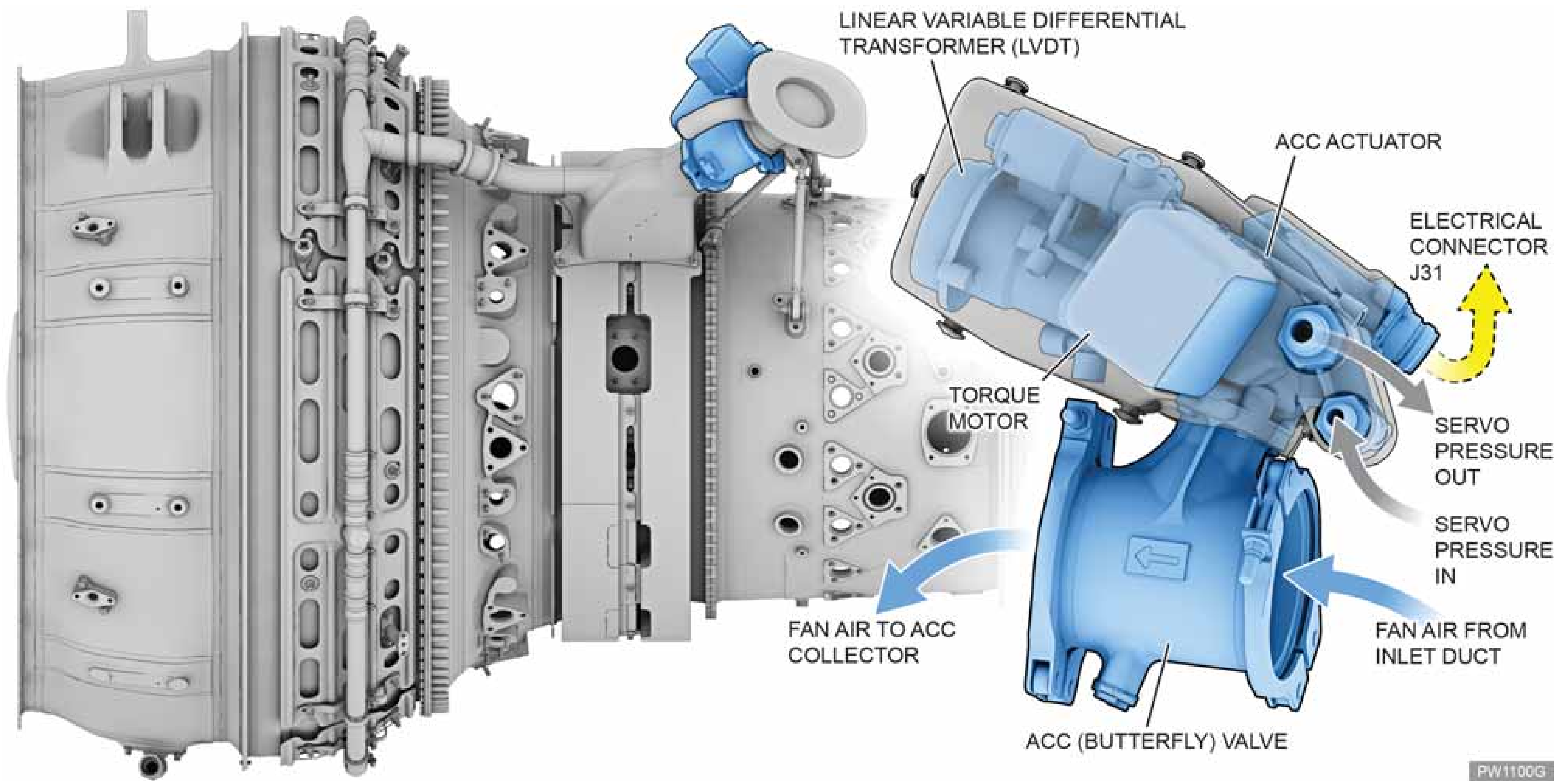
1. During engine operation, the EEC sends electrical command signals to a dual channel torque motor that is part of the valve and actuator.

2. The torque motor uses the signals to direct pressurized fuel to either side of the actuator piston to achieve the commanded position.

3. The piston opens and closes the butterfly valve, sending bypass airflow to the HPT and LPT case cooling manifolds. The airflow cools and actively controls turbine case expansion to match the radial expansion of the rotor.

During normal engine operation, the valve is closed at start and idle, partially open at takeoff and climb, and fully open at cruise.

In the event of electrical power loss, the fail-safe mode of the valve and actuator is closed.



ACTIVE CLEARANCE CONTROL SYSTEM – ACC VALVE AND ACTUATOR

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM (Cont.)

ACC Collector

Purpose: LRU

The ACC Collector distributes fan cooling air to the ACC HPT and LPT manifolds.

Location:

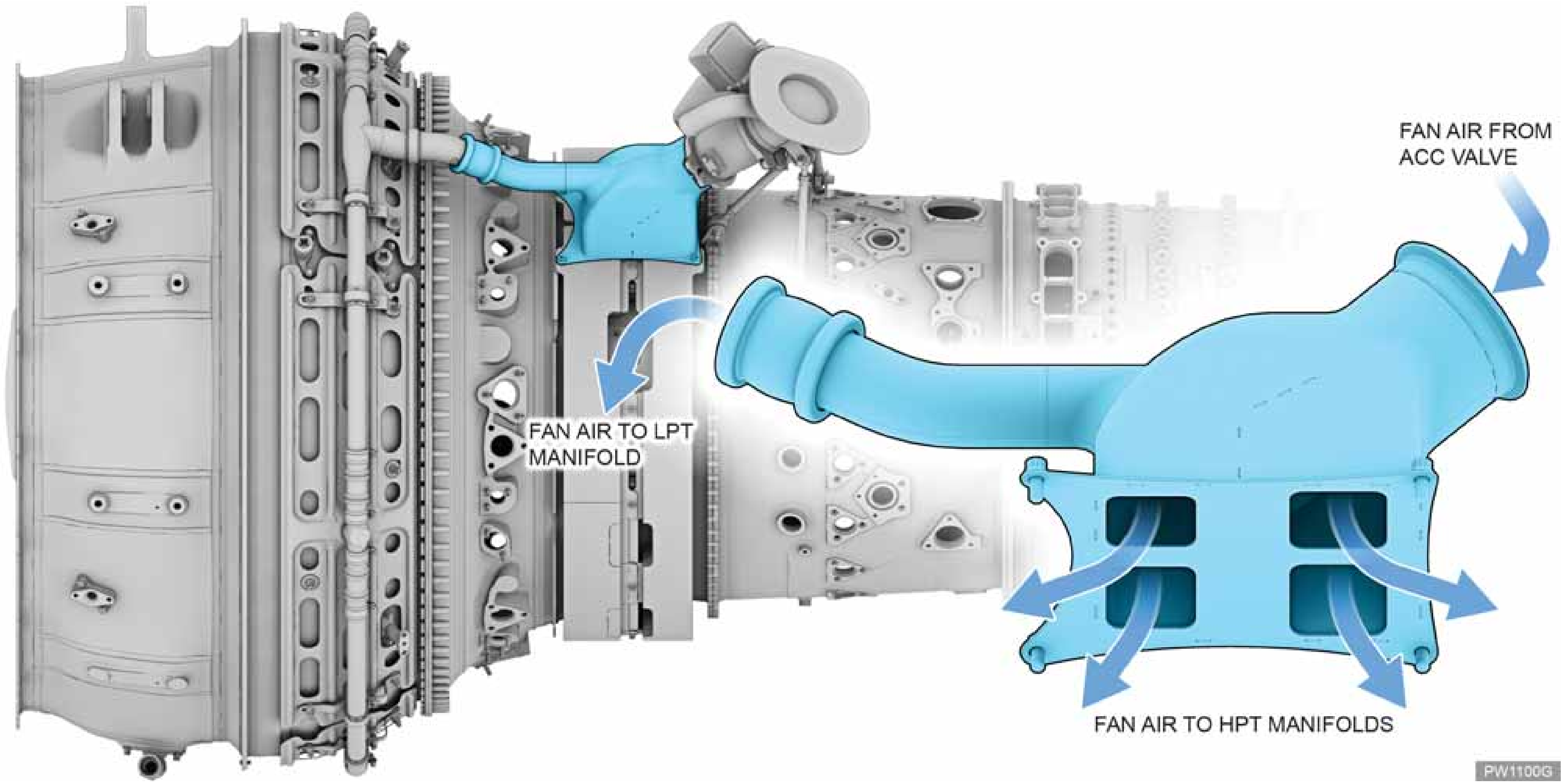
The collector is located at 2:00 on the HPT case.

Description:

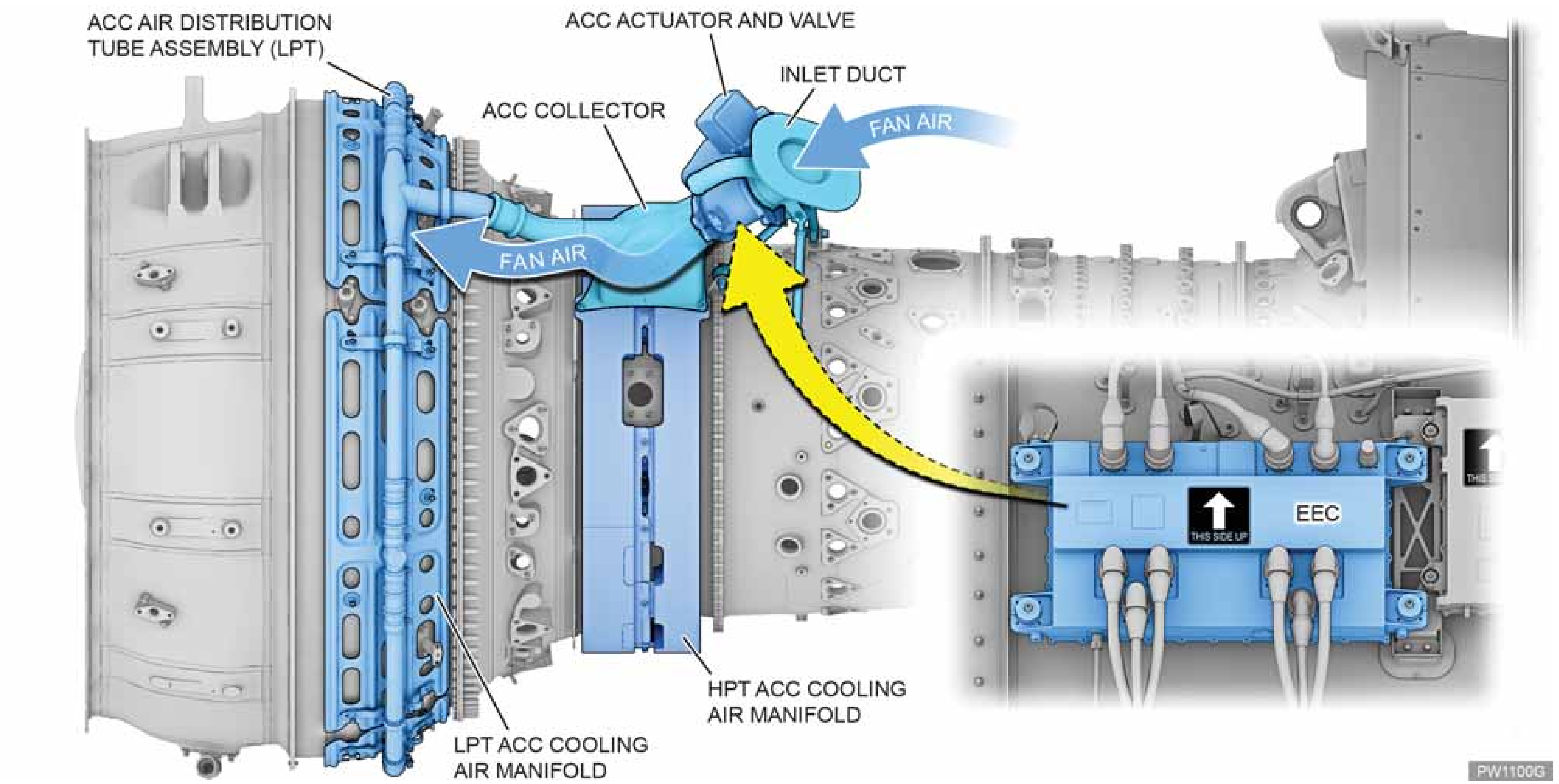
The stainless steel collector is attached to the HPT ACC manifolds with four bolts, and attached to the LPT ACC tube using a coupling and two packings. The packings prevent cooling air leakage.

Operation:

Fan air is routed from the ACC valve into the collector and directed separately to the HPT and LPT manifolds.



ACTIVE CLEARANCE CONTROL SYSTEM – ACC COLLECTOR



ACTIVE CLEARANCE CONTROL (ACC) SYSTEM – FAN AIRFLOW

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM (Cont.)

HPT ACC Cooling Air Manifolds

Purpose:

HPT ACC cooling air manifolds receive cooling air from the ACC collector and distribute it around the inside of the manifolds.

Location:

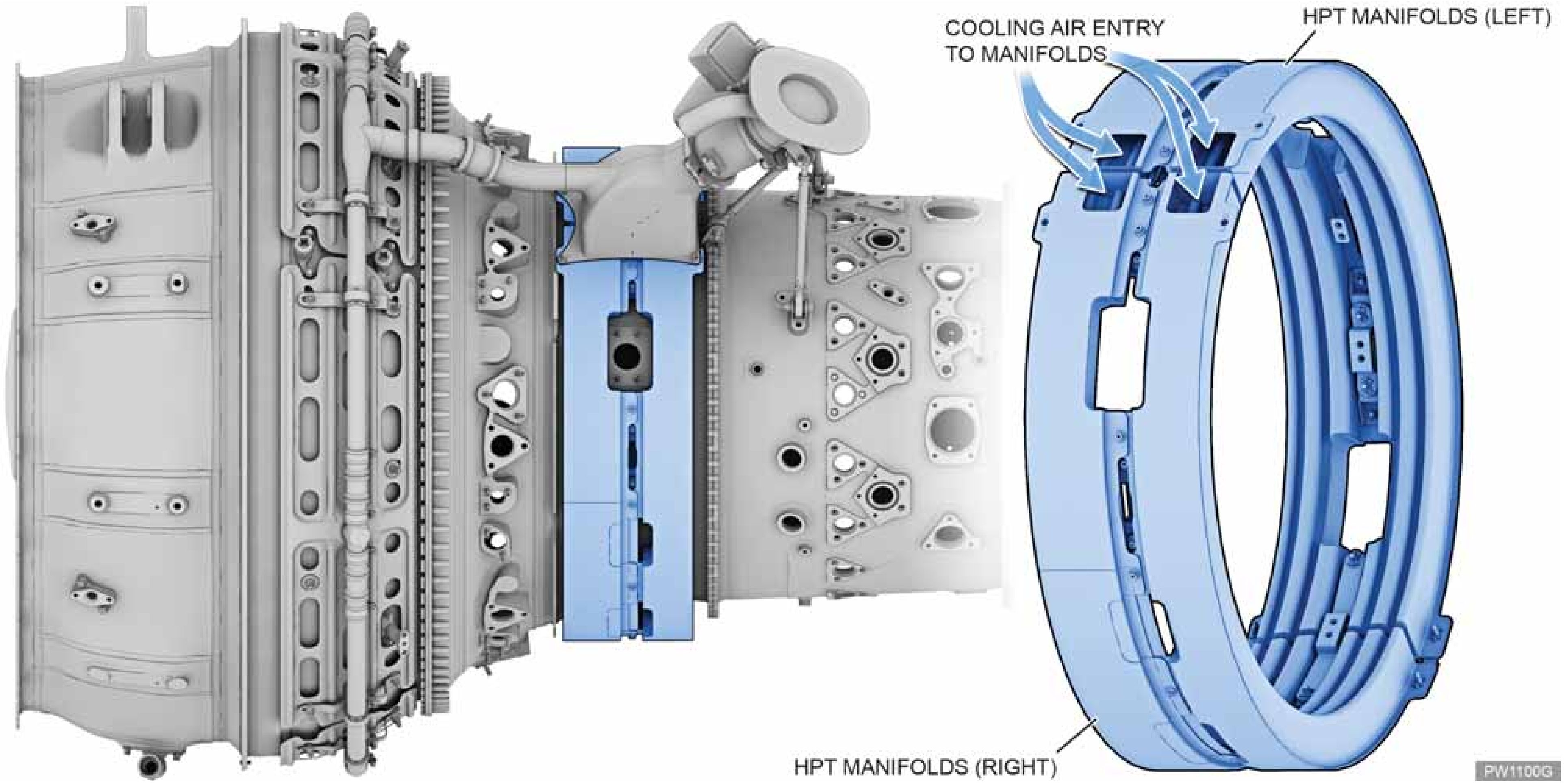
The manifolds are located around the diameter of the HPT case.

Description:

Two sets of stainless steel manifolds (left and right) are installed on the outside of the HPT case in the same radial plane as the 1^{st} and 2^{nd} stage HPT blades. They are attached with brackets and bolts to the M and N flanges of the HPT case.

Operation:

Cooling air exits the manifolds through small holes on the inner diameter, cooling the HPT case.



ACTIVE CLEARANCE CONTROL SYSTEM – HPT COOLING AIR MANIFOLDS

ACTIVE CLEARANCE CONTROL (ACC) SYSTEM (Cont.)

LPT ACC Cooling Air Manifolds

Purpose:

LPT ACC cooling air manifolds supply cooling air from the ACC collector to the outside of the LPT case, limiting thermal expansion.

Location:

The manifolds are located around the diameter of the LPT case.

Description:

The stainless steel manifolds are installed onto 24 studs in the LPT outer case and secured with 24 nuts. Each manifold has an integral tube stand-off that mates with a manifold connector on the LPT ACC Air Distribution Tube Assembly.

LPT ACC Air Distribution Tube Assembly

Purpose:

The LPT ACC Air Distribution Tube Assembly receives cooling air from the ACC collector and distributes the air onto the LPT case.

Location:

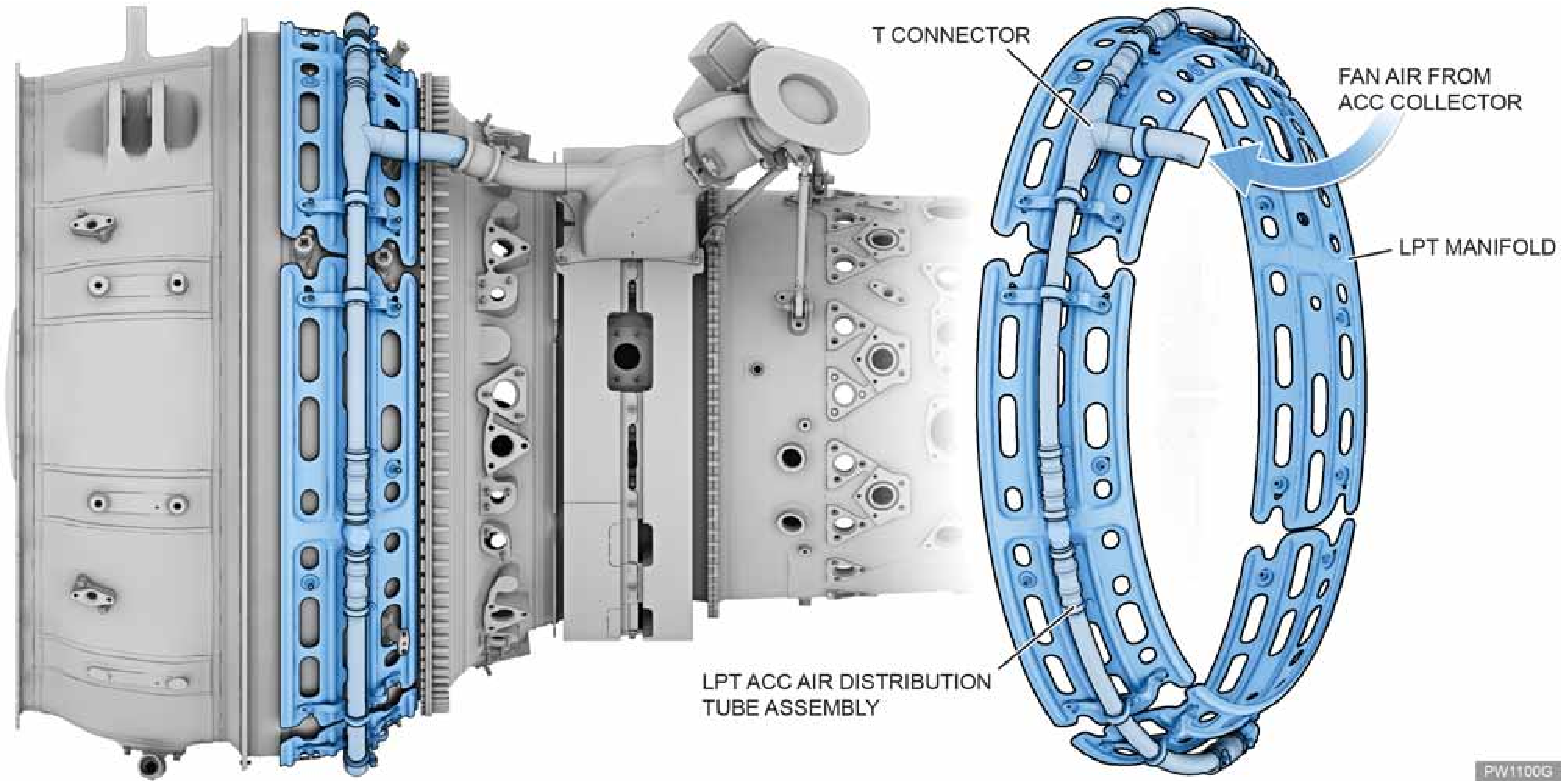
The assembly is attached to the LPT case.

Description:

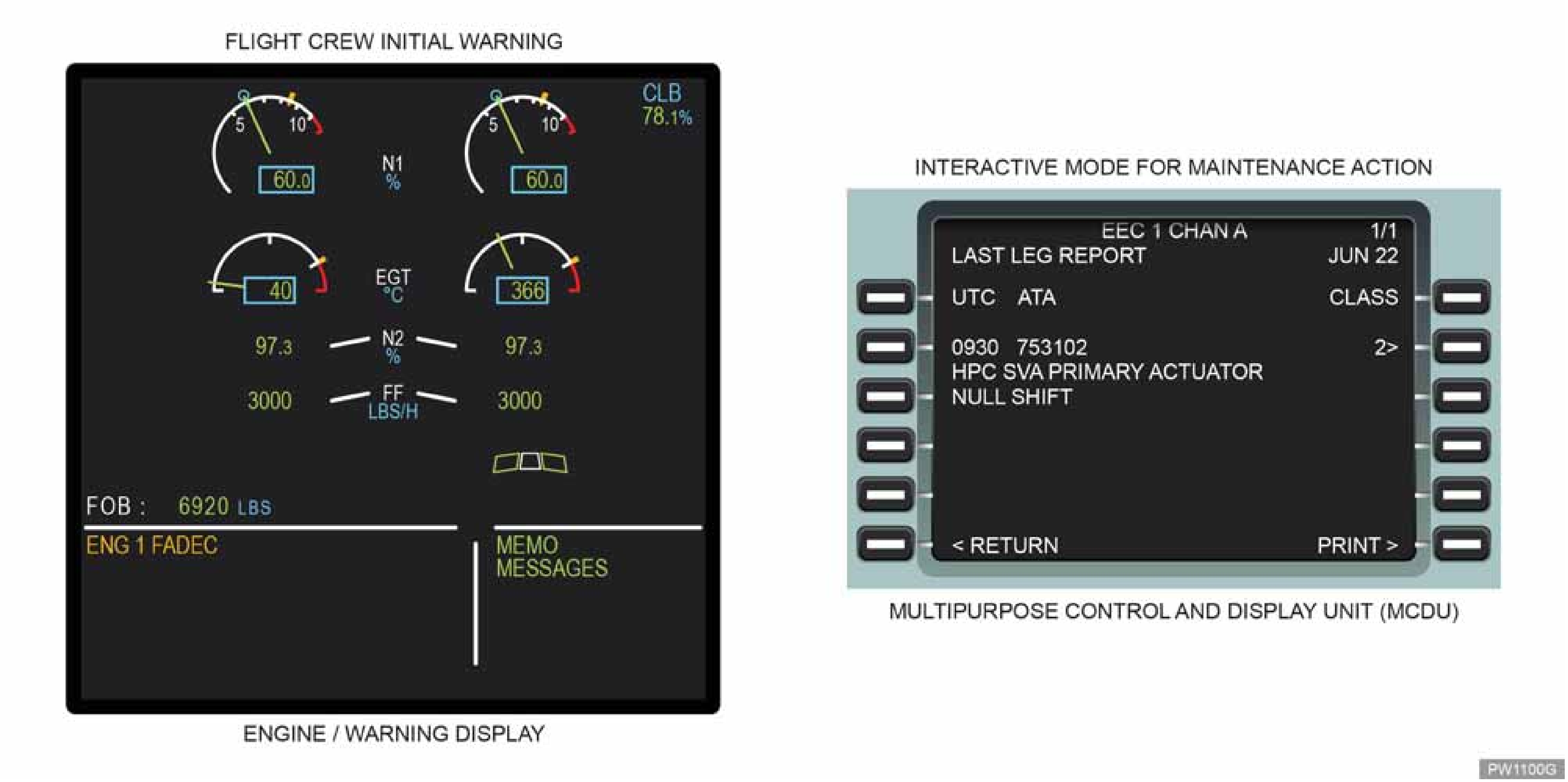
The assembly consists of three separate sections, six tube couplings and four manifold connectors. One of the three tube sections has an integral T-connector that receives air from the ACC collector.

Tube couplings connect the tube sections to the manifold connectors. The couplings fit over the outside diameter of the tube sections and manifold connectors, and are secured with 12 clamps.

The tube sections are attached to the LPT case with seven clamps installed on seven brackets attached to the case studs.



ACTIVE CLEARANCE CONTROL SYSTEM – LPT COOLING AIR MANIFOLDS



SAMPLE ECAM MESSAGES FOR ATA 75

CHAPTER 5

IGNITION

ATA 74

SYMBOLS

Symbols used in this guide are explained below.

Special tooling is required.

LRU — The component is a Line Replaceable Unit (LRU).

PMT ✓ — A Post Maintenance Test is required.

WARNING — Avoid injury by following guidelines listed under this symbol.

CAUTION — Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of the Ignition System.
2. Locate system components.
3. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Ignition System supplies a spark to ignite the fuel/air mixture in the combustor. Ignition occurs during engine start, engine relight, and when conditions require a continuous ignition to prevent the risk of flameout.

Each engine has two independent ignition systems designed for continuous duty operation if needed. Normally the systems alternate, but they can be used simultaneously under these conditions:

- continuous ignition
- manual start
- automatic re-start
- in-flight start
- failed igniter on both EEC channels
- high altitude or extreme cold ground start.

The Electronic Engine Control (EEC) commands the Ignition System in both manual and automatic start modes. Auto start is the normal condition, and manual mode is used if auto start fails, or for maintenance purposes.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE MSDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

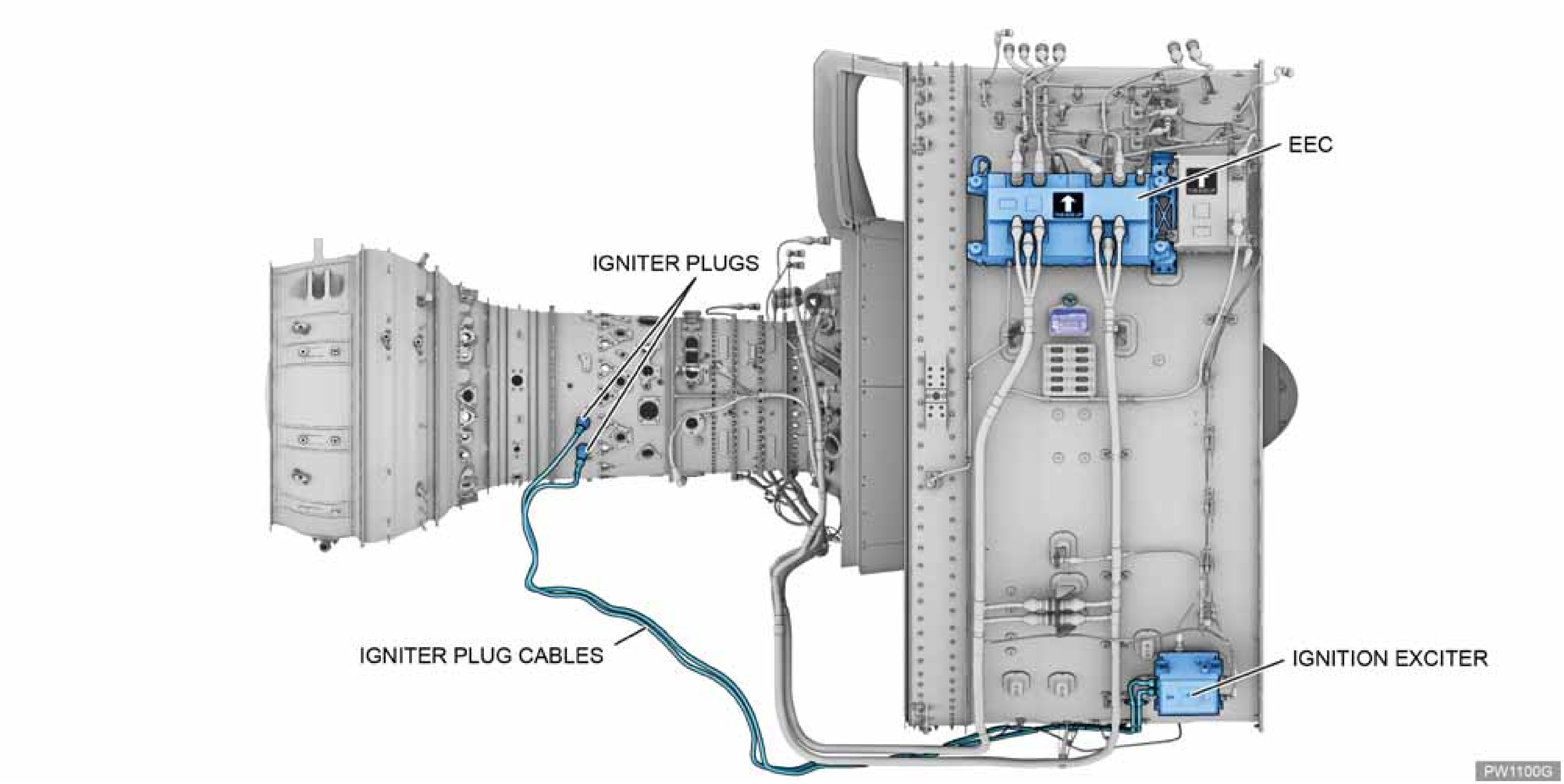
THE IGNITION SWITCH MUST BE IN THE OFF POSITION BEFORE YOU REMOVE IGNITION COMPONENTS. SOME MINUTES MUST GO BY BEFORE IT IS SAFE TO REMOVE IGNITION COMPONENTS. AFTER YOU REMOVE THE IGNITER PLUG CABLE FROM THE IGNITER PLUG, IMMEDIATELY TOUCH THE CABLE TERMINCAL TO A GOOD GROUND TO LET ALL OF THE ELECTRICAL ENERGY OUT OF THE SYSTEM. THE IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. IF YOU DO NOT DO THIS PROCEDURE, INJURY OR DEATH CAN BE THE RESULT.

USE NECESSARY PRECAUTIONS WHEN YOU DO WORK ON THE IGNITION SYSTEM. THIS SYSTEM HAS HIGH ENERGY AND CAN CAUSE INJURY OR DEATH BY ELECTRICAL SHOCK.

CAUTION

DO NOT BEND OR TWIST THE IGNITION CABLES. REMOVE THE CABLE ENDS STRAIGHT FROM THE IGNITER PLUG RECEPTACLES. IF NECESSARY, REMOVE THE IGNITION CABLE FROM THE SPRING CLIPS TO RELEASE TENSION FROM THE CABLE. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE CABLE ENDS AND/OR IGNITER PLUG CERAMIC.

Each of the two systems includes an ignition exciter, igniter plug cables, and igniter plugs.



IGNITION SYSTEM

COMPONENTS

Ignition Exciter

Purpose:

LRU PMT

The ignition exciter supplies the voltage necessary for igniter plug operation.

Location:

The exciter is attached by anti-shock mounts to a bracket on the fan case at 5:00.

Description:

The exciter receives 115V AC electrical input power from the aircraft to ignite the fuel/air mixture in the combustor.

Operation:

The ignition exciter supplies 8 kilovolts to the igniter plugs to ignite the fuel/air mixture in the combustor. The exciter duty cycle varies between 1–3 sparks per second.

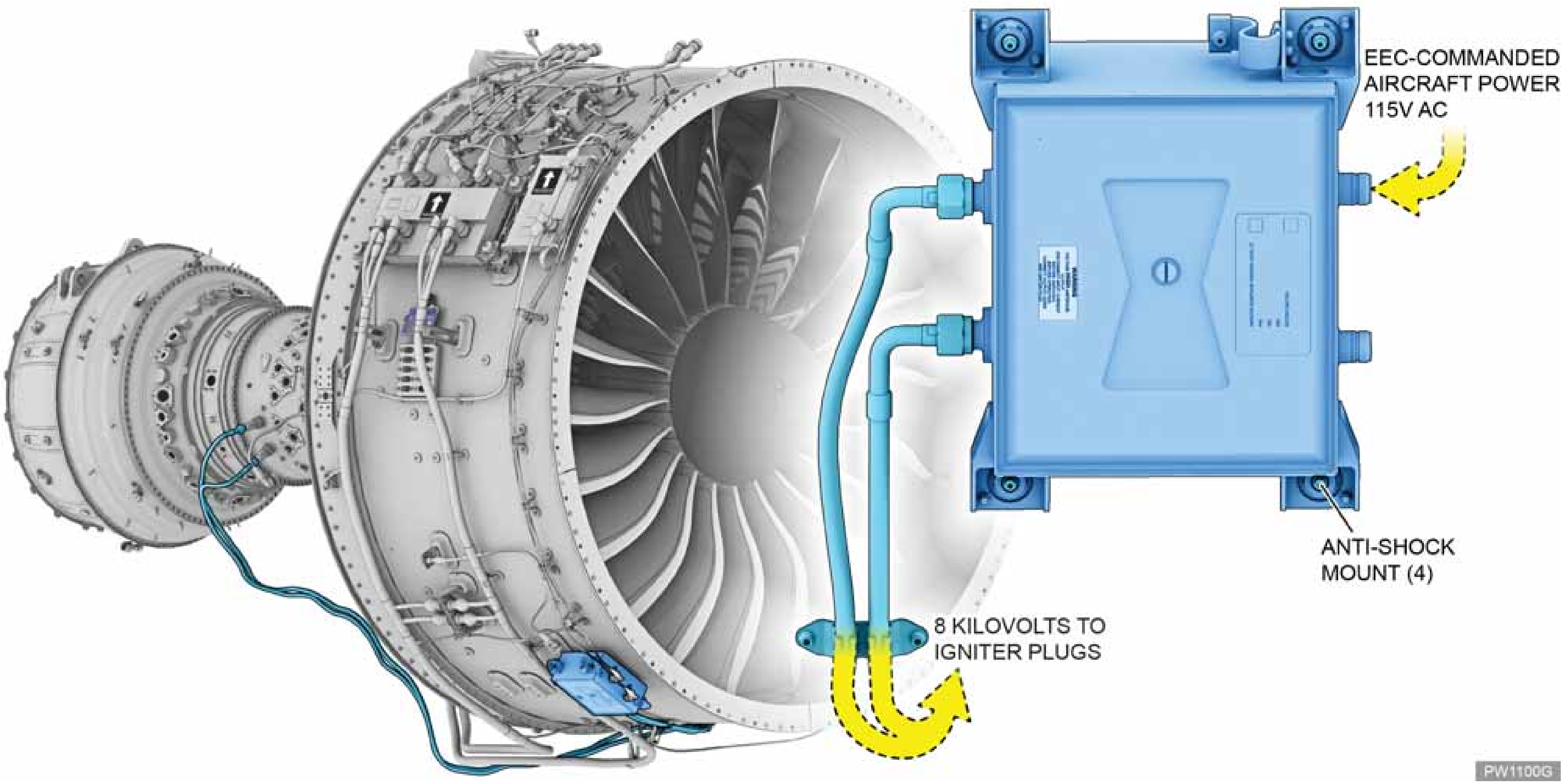
Safety Conditions

CAUTION

BE SURE TO TIGHTEN IGNITION CONNECTOR NUTS TO THE CORRECT TORQUE. IF THE TORQUE AT EITHER THE IGNITER PLUG OR IGNITION EXCITER END OF THE CABLE IS NOT SUFFICIENT, THIS CAN CAUSE ELECTRICAL NOISE FROM THE IGNITION SYSTEM IN THE AIRCRAFT RADIO EQUIPMENT.

An EEC command activates the exciter circuits when ignition is requested from the flight deck.

The ignition exciter has an energy delivery capacity of 0.9 joules/channel. Fan compartment air flows over the hermitically sealed exciter box to provide cooling for the unit.



IGNITION EXCITER

COMPONENTS (Cont.)

Igniter Plug Cables

Purpose:

LRU PMT

Igniter plug cables distribute electricity from an exciter to an igniter plug.

Location:

Cables are routed from the ignition exciter on the right side of the engine fan case at 5:00, to the igniters installed on the diffuser case at 3:00 and 4:00 on the right side of the engine.

Description:

The interchangeable cables are flexible braided-steel conduits with ceramic insulated terminals at the plug end.

Operation:

The igniter plug cables send 8 kilovolts of electricity from an exciter to an igniter plug.

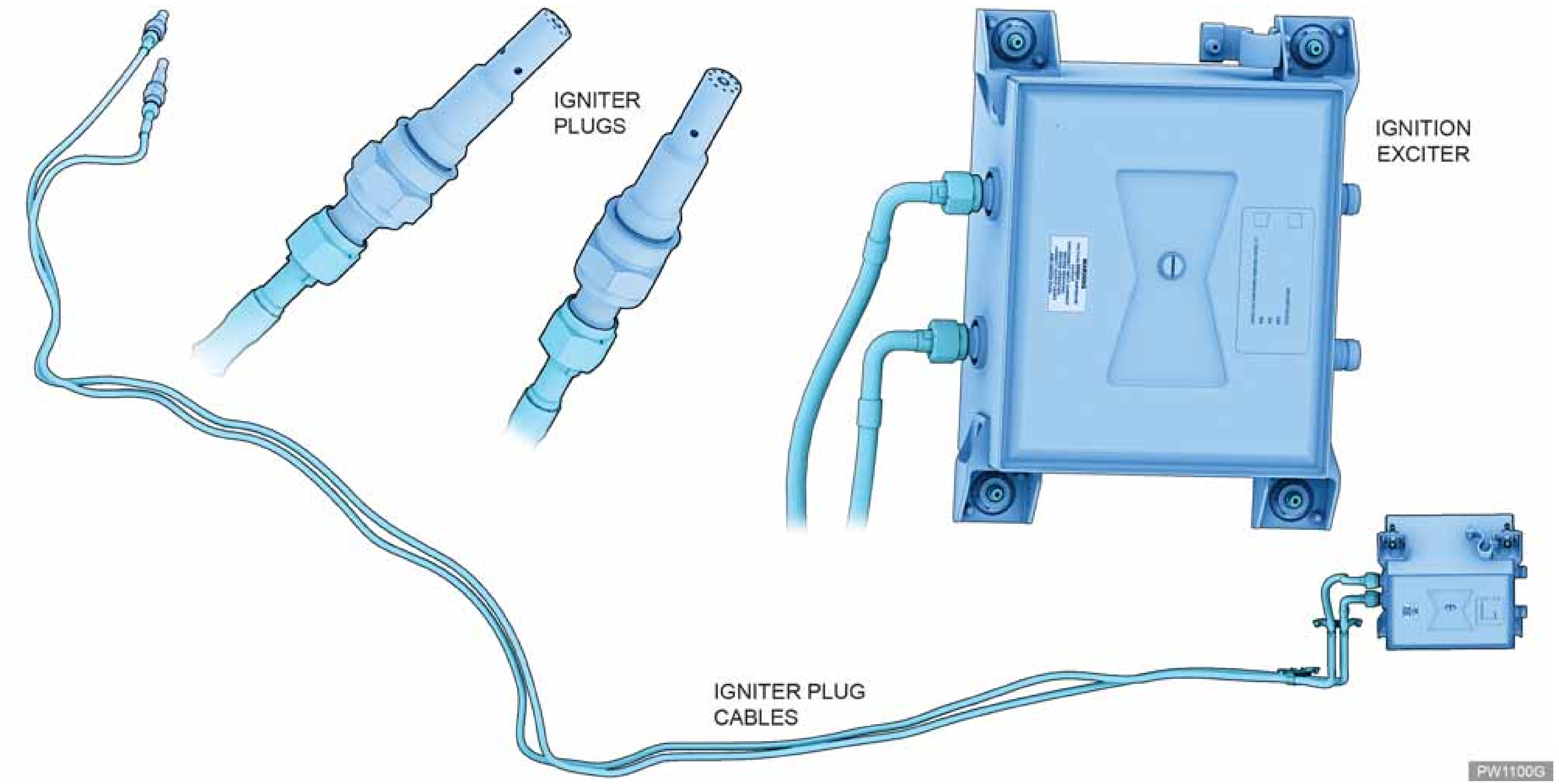
Safety Conditions

WARNING

IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. THE IGNITION SWITCH MUST BE IN THE OFF POSITION BEFORE REMOVING OR INSTALLING ANY IGNITION COMPONENTS. AFTER DISCONNECTING CABLE FROM IGNITER PLUG, DISCHARGE CURRENT BY GROUNDING CABLE TERMINAL TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM. FAILURE TO FOLLOW THIS PROCEDURE COULD RESULT IN SEVERE INJURY TO PERSONNEL.

CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.



IGNITION SYSTEM COMPONENTS

COMPONENTS (Cont.)

Igniter Plugs

Purpose:

LRU

Igniter plugs are used to ignite the fuel/air mixture for engine start.

Location:

The plugs are attached to the diffuser case at 3:00 and 4:00.

Description:

Each igniter plug has shielded center electrodes. Classified spacers are installed under a mounting boss. The spacers and boss are installed to the diffuser case assembly and are not removed during replacement of the igniter plugs.

Operation:

The spacers control immersion depth of the igniter plug tip inside the combustion chamber. Each igniter plug uses 8 kilovolts from an exciter to make an electrical spark across the igniter plug gap. The spark from the plug ignites the fuel/air mixture.

Safety Conditions

WARNING

THE IGNITION SWITCH MUST BE IN THE OFF POSITION FOR TWO MINUTES MINIMUM BEFORE YOU REMOVE IGNITION COMPONENTS. YOU MUST WAIT THE TWO MINUTES TO LET ALL OF THE ELECTRICAL ENERGY OUT OF THE SYSTEM. THE IGNITION SYSTEM VOLTAGE IS DANGEROUSLY HIGH. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

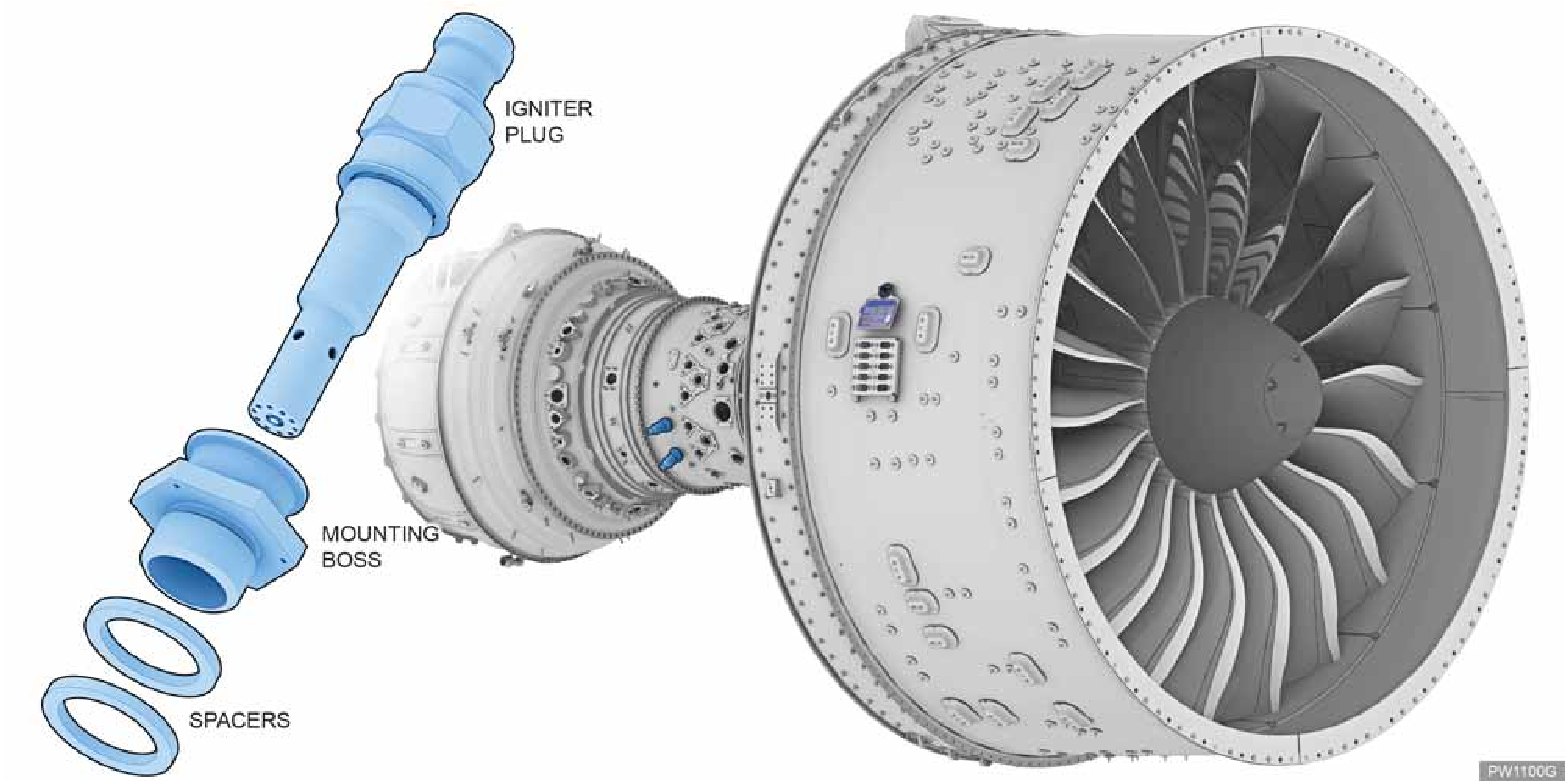
DO NOT BEND OR TWIST THE IGNITION CABLES. REMOVE THE CABLE ENDS STRAIGHT FROM THE IGNITER PLUG RECEPTACLES. IF NECESSARY, REMOVE THE IGNITION CABLE FROM THE SPRING CLIPS TO RELEASE TENSION FROM THE CABLE. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE CABLE ENDS AND/OR IGNITER PLUG CERAMIC.

HOLD THE INSERT WITH THE ADAPTER WHEN YOU REMOVE THE IGNITER PLUG. FAILURE TO HOLD THE IGNITER BOSS INSERT WHEN THE IGNITER PLUG IS REMOVED MAY RESULT IN LOSS OF TORQUE ON THE INSERT AND ENGINE DAMAGE.

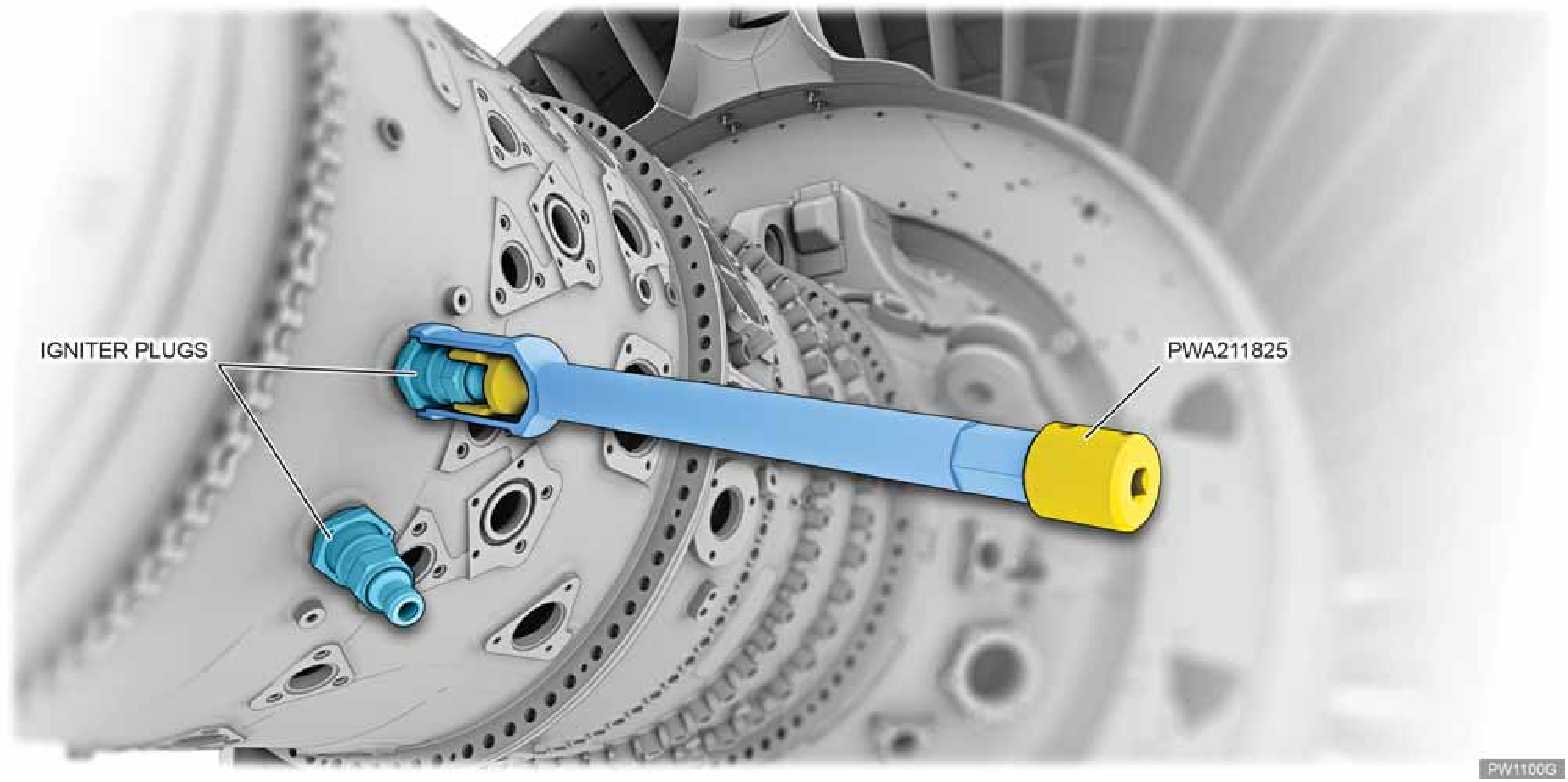
DO NOT USE A THREAD CHASING DIE ON THE IGNITER PLUG. THE THREADS ARE SILVER PLATED AND HAVE A TIGHT TOLERANCE TO MAKE SURE THE IGNITER PLUG FITS CORRECTLY. DO NOT CLEAN THE IGNITER PLUG THREADS TOO MUCH. IF YOU DO NOT OBEY THIS CAUTION, DAMAGE TO THE IGNITER PLUG CAN OCCUR.

DO NOT APPLY ANTI-SEIZE TO THE THREADS OF THE PLUG. ANTI-SEIZE CAN CHANGE THE TORQUE AND CAUSE DAMAGE TO THE INSERT.

Igniter remover adapter tool PWA211825 is required to remove either igniter plug, once the electrical system has been de-energized.



IGNITER PLUG



IGNITER REMOVER ADAPTER TOOL

IGNITION SYSTEM OPERATION

Aircraft 115V AC power for the exciters is wired to an exciter box containing solid state relays controlled by the EEC. The exciter box contains the circuits for both igniters, which are electrically isolated within the exciter box.

Electrical power is supplied to the exciter box by bus power as shown below.

Engine	Ignition System	Bus Power
1	A	AC Essential
	B	AC 1
2	A	AC Essential
	B	AC 2

Exciter box circuit relays are controlled via ignition commands from the integrated flight deck control panel to the EEC. The electrical energy from the ignition exciters is then sent through the ignition cables to the igniter plugs.

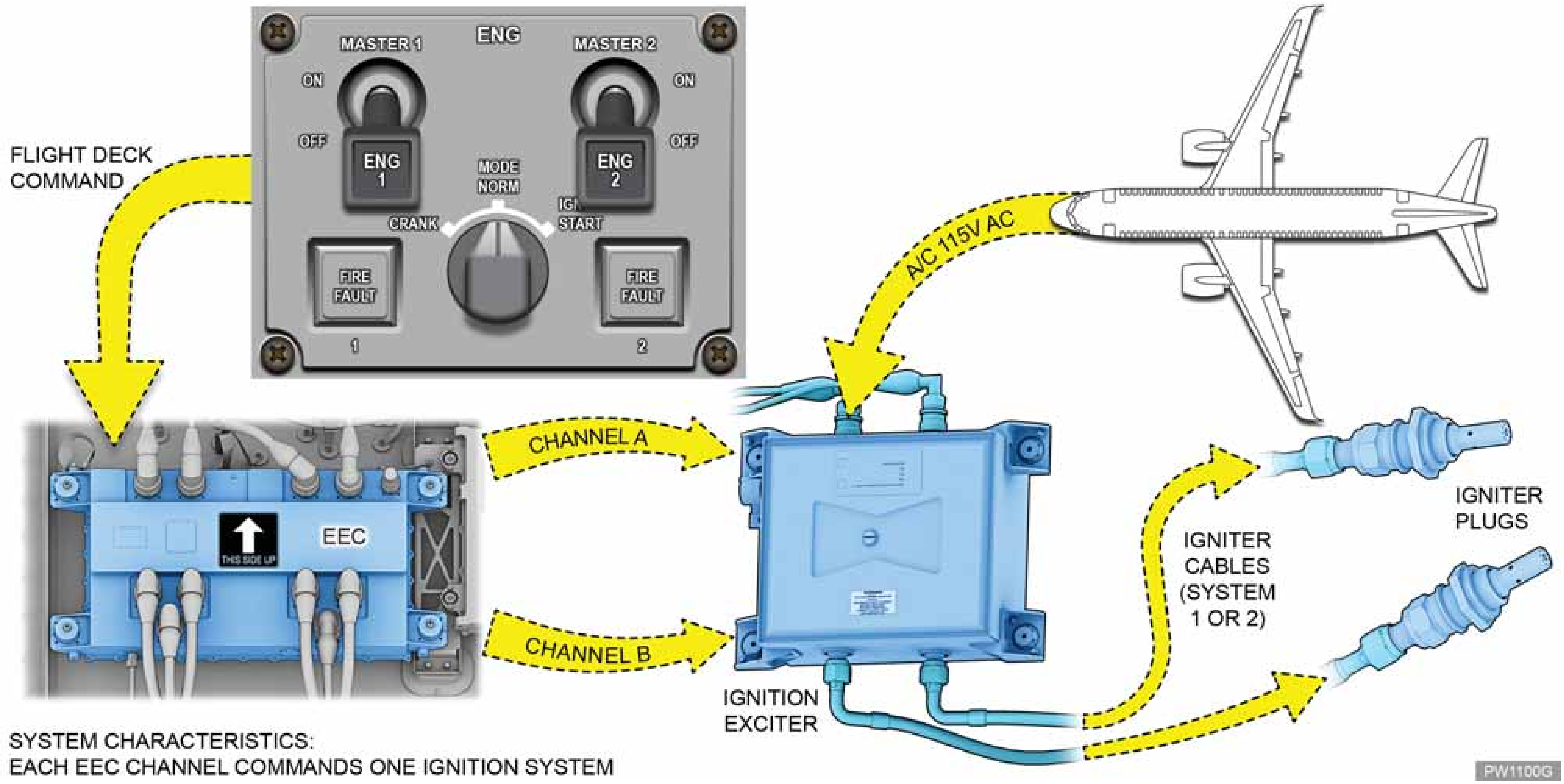
When using the Manual Start Ignition selection, the EEC commands the Starter Air Valve (SAV) open, energizes igniters, and starts fuel flow.

The EEC includes an Automatic Ignition System as an integral part of its ignition function. It also features an Automatic Relight System, which energizes both igniters for 30 seconds when engine flameout is detected in RUN position.

Alternating the igniters every other start attempt instead of every start attempt allows each channel to be tested with each igniter every two starts.

The EEC will automatically select dual-igniter continuous ignition in the conditions below.

- An engine flameout is detected in flight or during takeoff.
- A surge is detected in flight or during takeoff. Igniters will be powered until 30 seconds after the surge recovers.
- The EEC detects a quick relight.
- The Thrust Control Malfunction (TCM) cutback (flare/approach or takeoff) is commanded to ensure the engine stays running after the rapid fuel cutback.

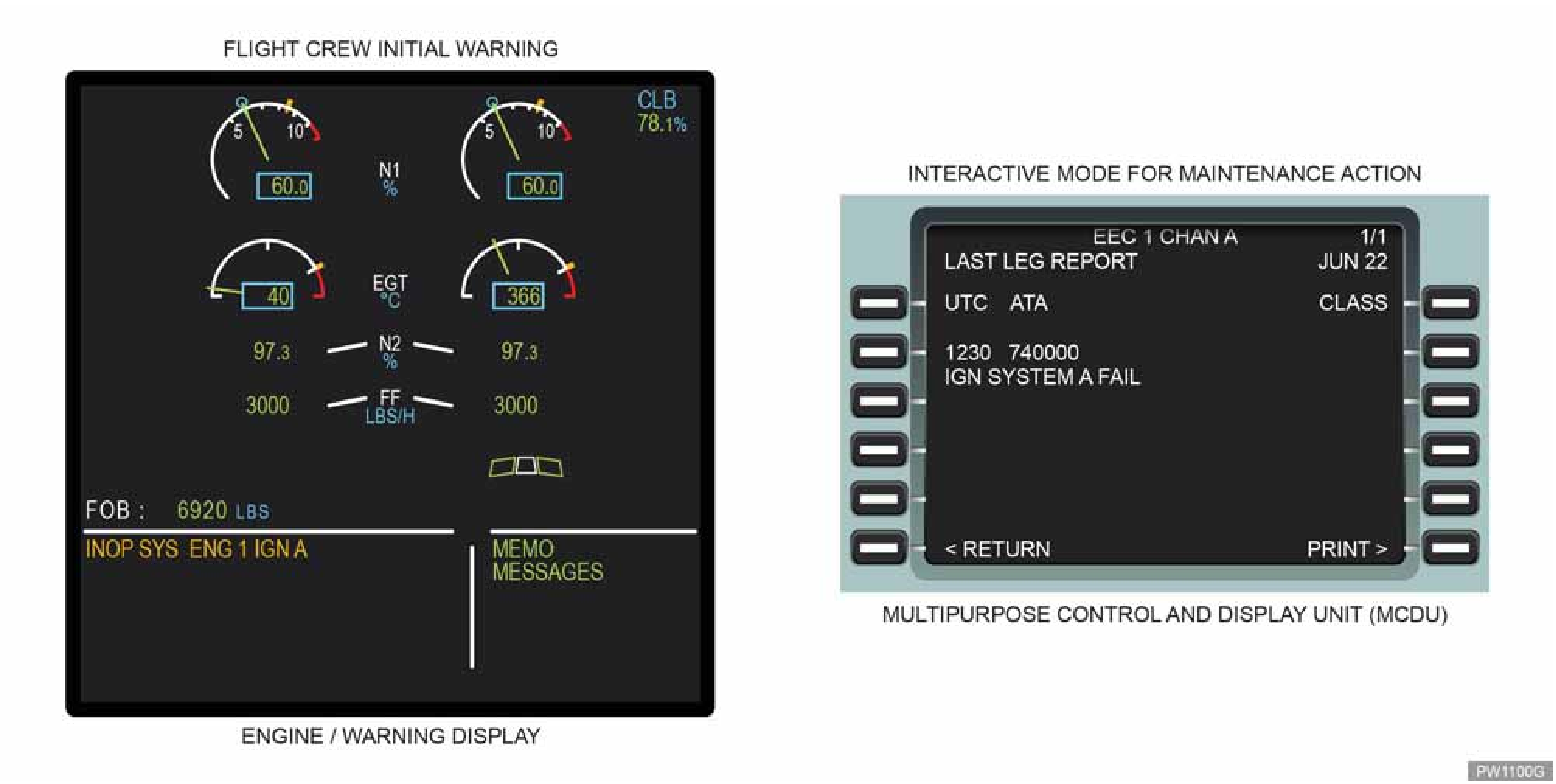


IGNITION SYSTEM OPERATION

IGNITION SYSTEM FAULT DISPLAY

The Electronic Centralized Aircraft Monitor (ECAM) receives fault messages from the Ignition System and displays them on the flight deck.

See the following page for a sample ECAM message for the Ignition System.



SAMPLE ECAM MESSAGES FOR ATA 74

CHAPTER 6

INDICATING

ATA 77

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT	A Post Maintenance Test is required.
WARNING	Avoid injury by following guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of the Indicating System.

2. Locate system components.

3. Explain how each of the three Indicating subsystems helps engine operations.

4. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Indicating System senses, analyzes, transmits, and provides flight deck display of engine operating parameters and information such as engine speeds, temperatures, vibration, and Electronic Centralized Aircraft Monitor (ECAM) messages.

These parameters represent the current operating state of the engine and the aircraft systems, and must be available to the crew at all times in order to maintain proper engine/aircraft control. Indications are located in front of each pilot and mainly show propulsion information as required by regulations and for engine operation.

Input from engine sensors and probes goes directly to the Electronic Engine Control (EEC) or to the Prognostics and Health Management Unit (PHMU), where the data is analyzed and calculations are performed.

The Indicating System is composed of three subsystems, described in the table.

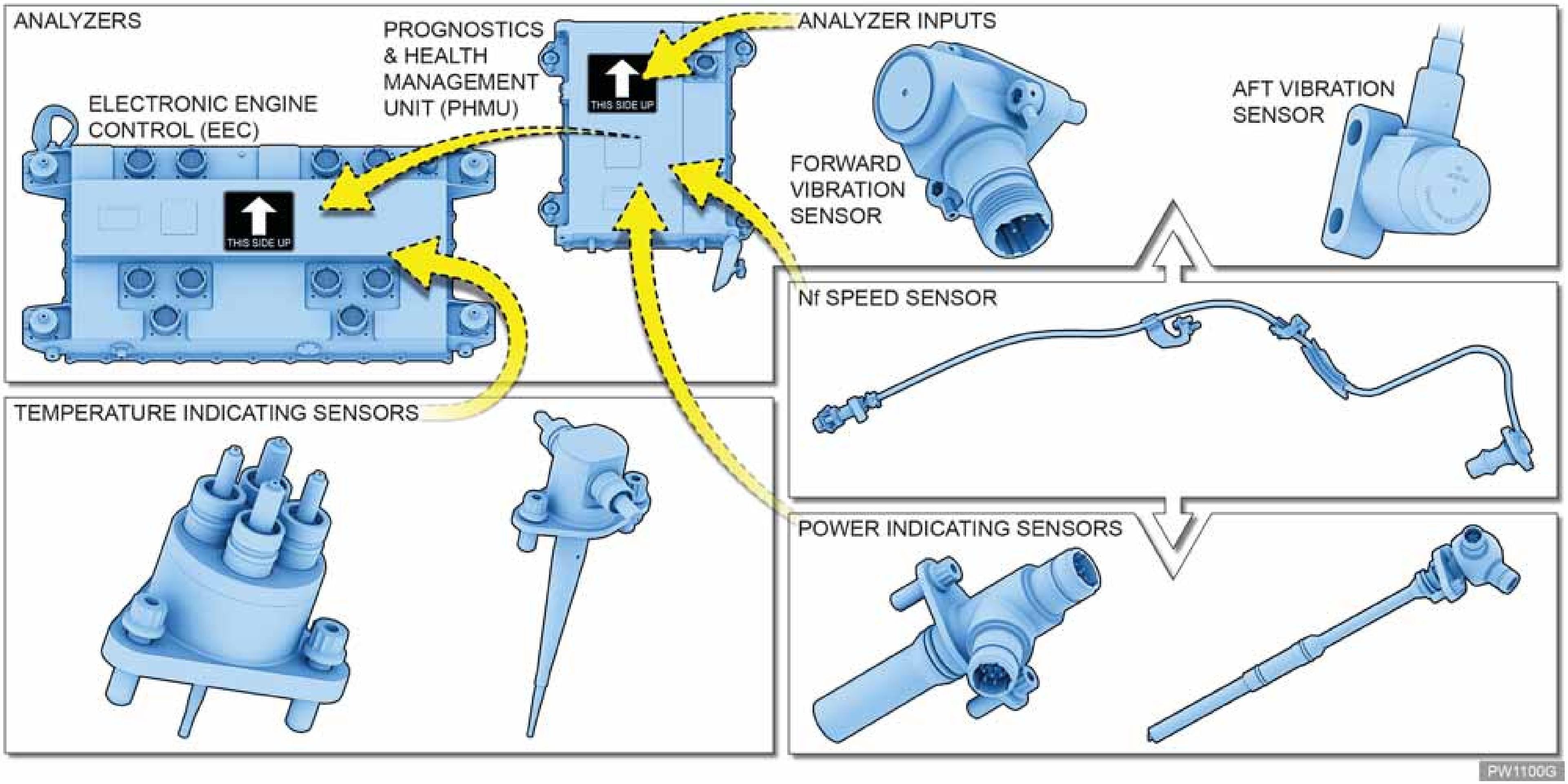
Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE MSDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

System	Indication
Power Indicating	Rotor speeds
Temperature Indicating	Exhaust Gas Temperature (EGT)
Analyzers	Engine vibration and health management, using data from engine sensors and components



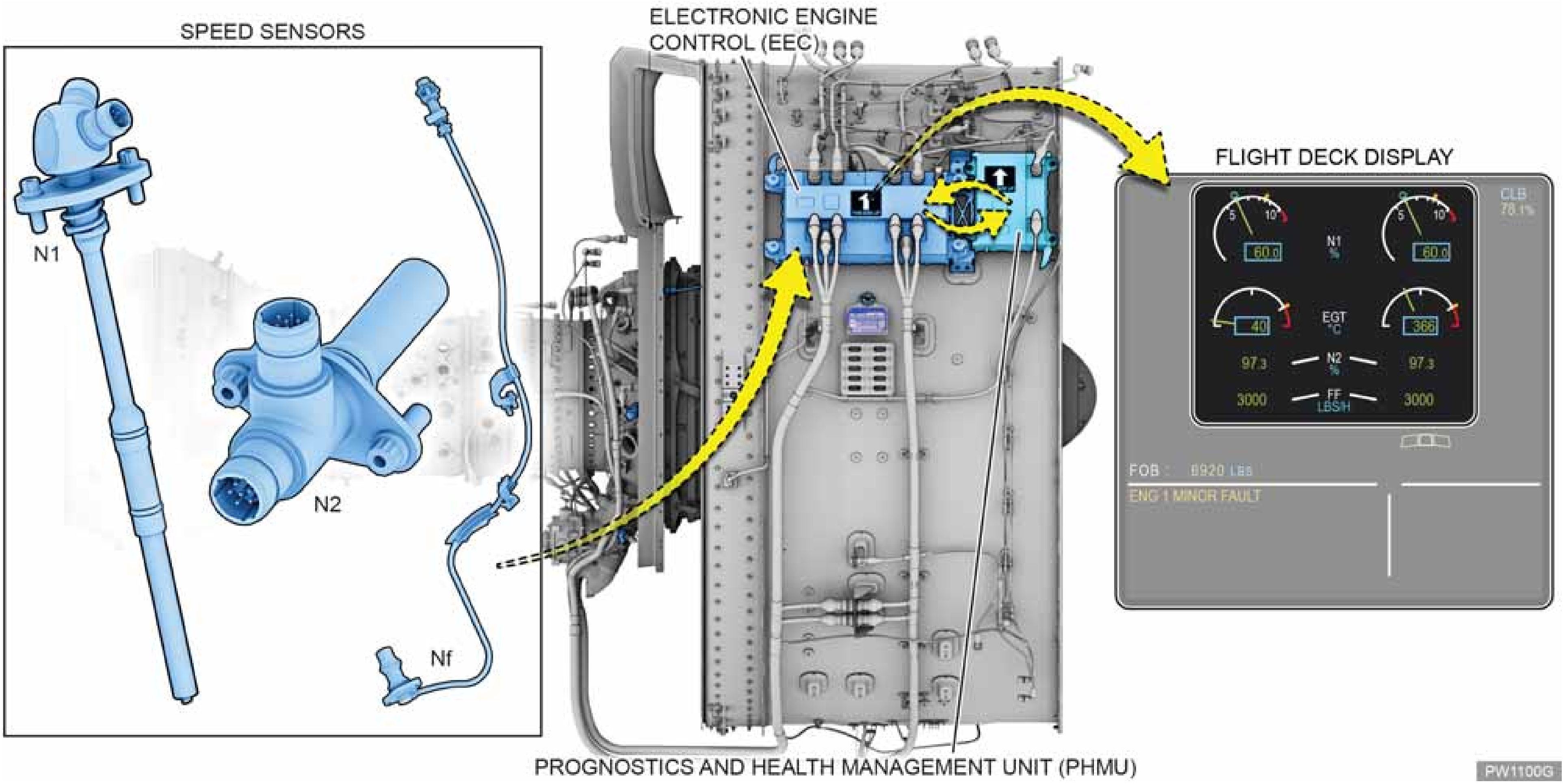
INDICATING SYSTEM SENSORS AND ANALYZERS

POWER INDICATING SYSTEM

The Power Indicating System senses and transmits speeds for the low rotor (N1), fan rotor (Nf), and high rotor (N2). Both the EEC and the Prognostics and Health Management Unit (PHMU) use these indications to control and monitor engine operations.

System components include the N1, N2 and Nf speed sensors, detailed in the chart.

<table>
<tr><th>Indicator</th><th>Function</th><th>Used By</th></tr>
<tr><td>N1</td><td>• Primary thrust control parameter</td><td rowspan="3">EEC</td></tr>
<tr><td>N2</td><td>• Fuel start and ignition control
• Overspeed monitoring</td></tr>
<tr><td rowspan="2">Nf</td><td>• Sheared input shaft detection</td></tr>
<tr><td>• Trim balancing</td><td>PHMU</td></tr>
</table>



POWER INDICATING SYSTEM OPERATION

POWER INDICATING SYSTEM (Cont.)

N1 Speed Sensor

Purpose:

LRU PMT

The N1 speed sensor transmits low rotor speed to the Electronic Engine Control, where the indication is used as the primary thrust control parameter for ECAM display.

Location:

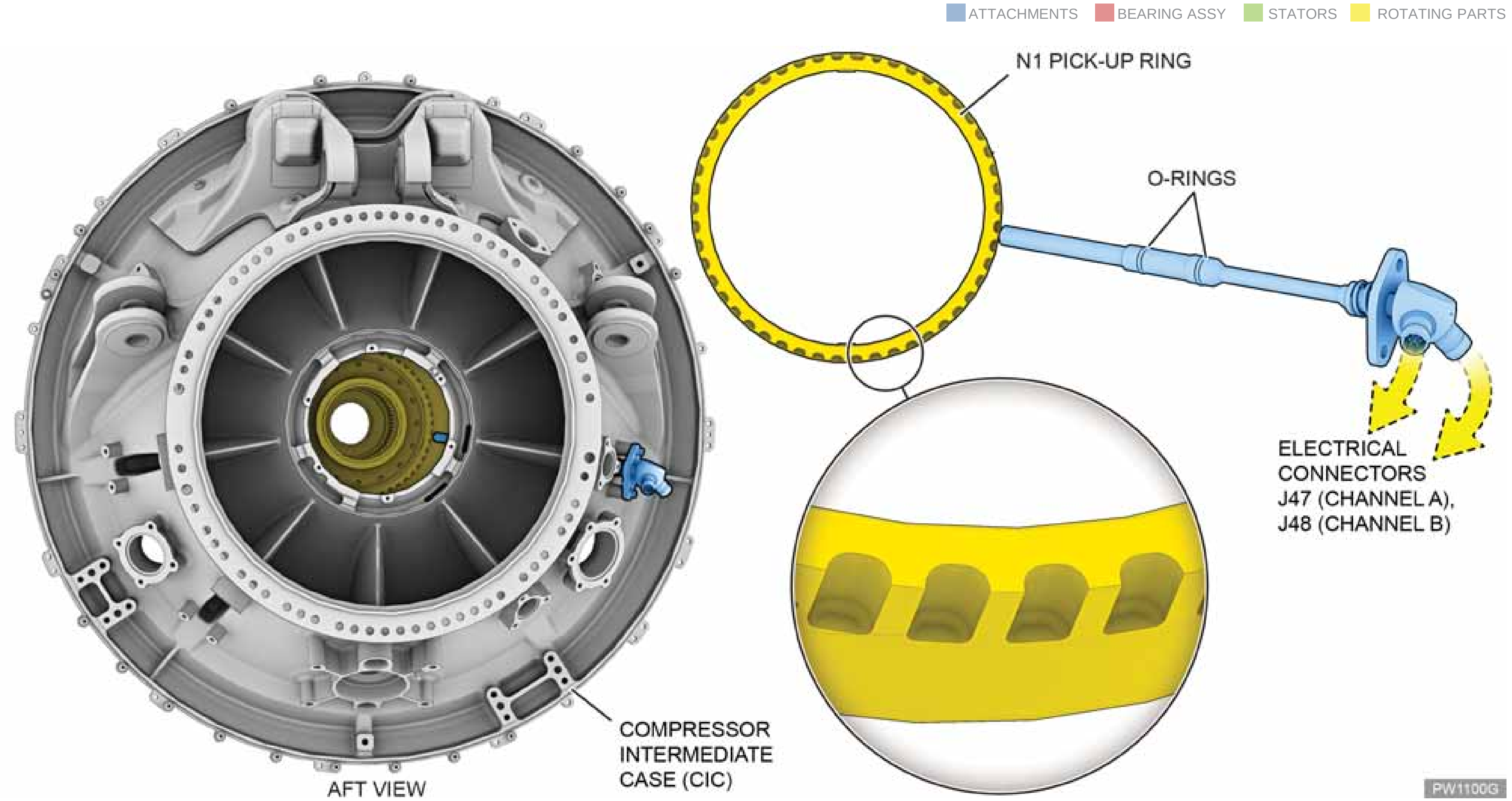
The N1 speed sensor is mounted on the rear of the Compressor Intermediate Case at approximately 4:00. The sensor is installed through the no. 4 strut of the CIC.

Description:

The probe is a dual-channel sensor having a common magnet stack with two independent, isolated coils and electrical connectors.

The tip gap between the tip of the N1 speed sensor and the teeth of the N1 pickup ring is set by the sensor's lower flange, which seats against a mating flange on the CIC. Tolerance stack-up is taken up by the spring located between the lower flange and the mount flange. Because of this design, no shimming is required when the sensor is installed new or replaced on-wing.

Two O-rings on the sensor body prevent oil from leaking out of the No. 3 Bearing compartment. If the N1 speed sensor is removed on-wing or during a shop visit, the O-rings should be replaced.



POWER INDICATING SYSTEM – N1 SPEED SENSOR (1 OF 2)

POWER INDICATING SYSTEM

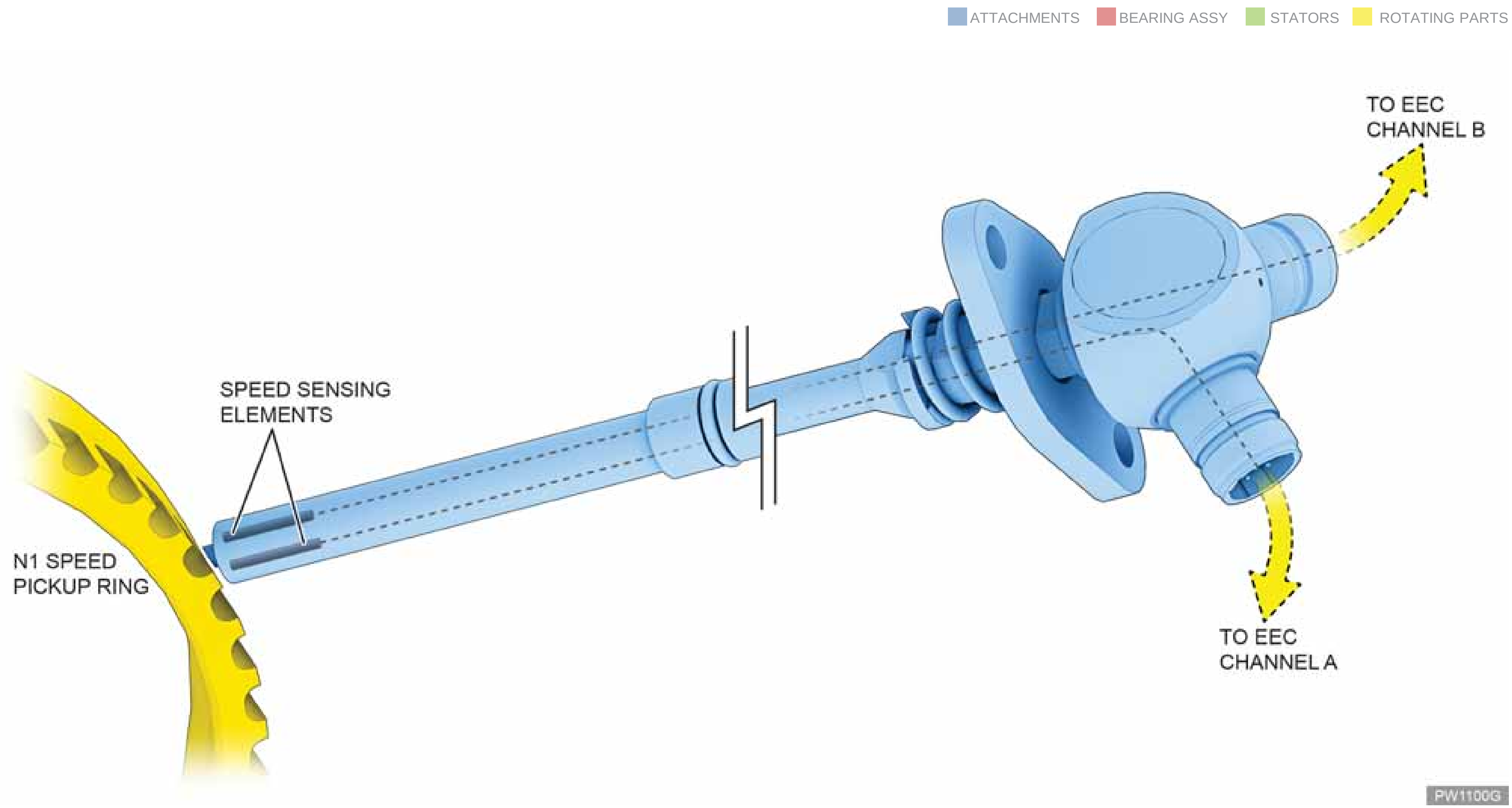
N1 Speed Sensor (Cont.)

Operation:

The N1 speed pickup ring has 20 teeth. One tooth on the pickup ring is shorter than the others and is identified by a dimple on the end.

Each time one of the teeth passes the N1 speed sensor, a change occurs in the magnetic field. The change produces a signal frequency that the EEC will use to calculate an N1 speed proportional to the coupling’s rotational speed. The short tooth will cause a different frequency which is used to locate zero degree for N1 trim balance purposes.

The upper limit, known as the *overspeed warning*, is set to N1 = 100 percent. When the indicator shows this level has been reached, the display changes to red, the master caution light illuminates, and a single chime sounds. At 105 percent N1, the overspeed solenoid in the IFPC will de-energize and fuel flow will decrease to idle.



POWER INDICATING SYSTEM – N1 SPEED SENSOR (2 OF 2)

POWER INDICATING SYSTEM (Cont.)

N2 Speed Sensor

Purpose: LRU PMT

The N2 speed coil senses and transmits N2 speed to both channels of the EEC, which uses the signal for control of fuel and ignition during starting, and also for monitoring overspeed condition of the high rotor.

Location:

The sensor is located on the right side of the Angle Gearbox (AGB) housing.

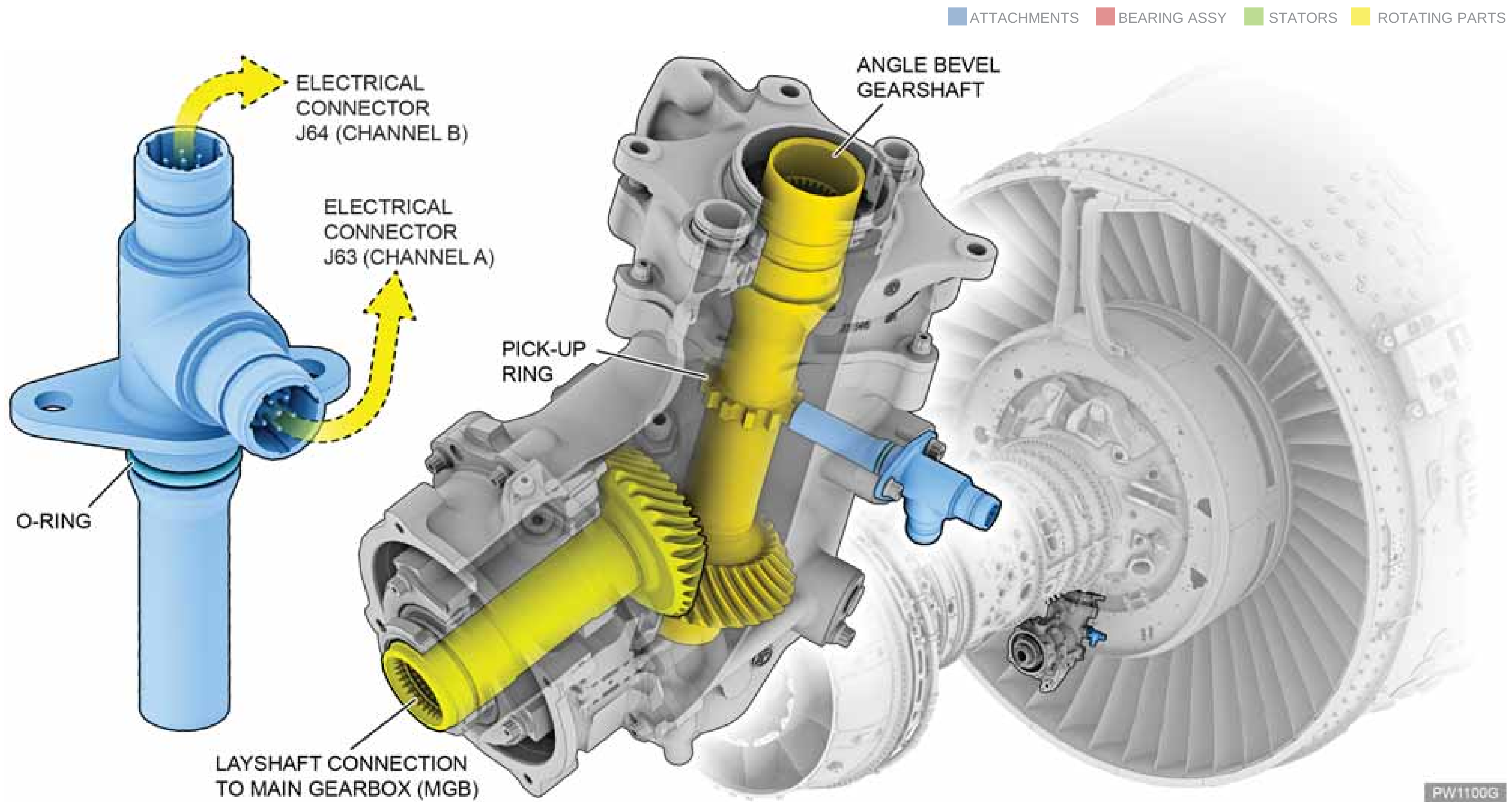
Description:

The N2 speed sensor is a one-piece sealed unit consisting of a dual-channel magnetic speed sensor using a single permanent magnet, two separate coils and two electrical connectors. The sensor is mounted with a two-bolt mounting flange.

The tip gap between the tip of the probe and the pickup ring in the AGB is set by the mount flange on the N2 speed sensor, which seats against a mating flange on the AGB housing.

This design means that no shimming is required when the sensor is installed new or replaced on-wing.

An O-ring on the sensor body prevents oil from leaking out of the AGB. If the N2 speed sensor is removed on-wing or during a shop visit, the O-ring should be replaced.



POWER INDICATING SYSTEM – N2 SPEED SENSOR (1 OF 2)

POWER INDICATING SYSTEM

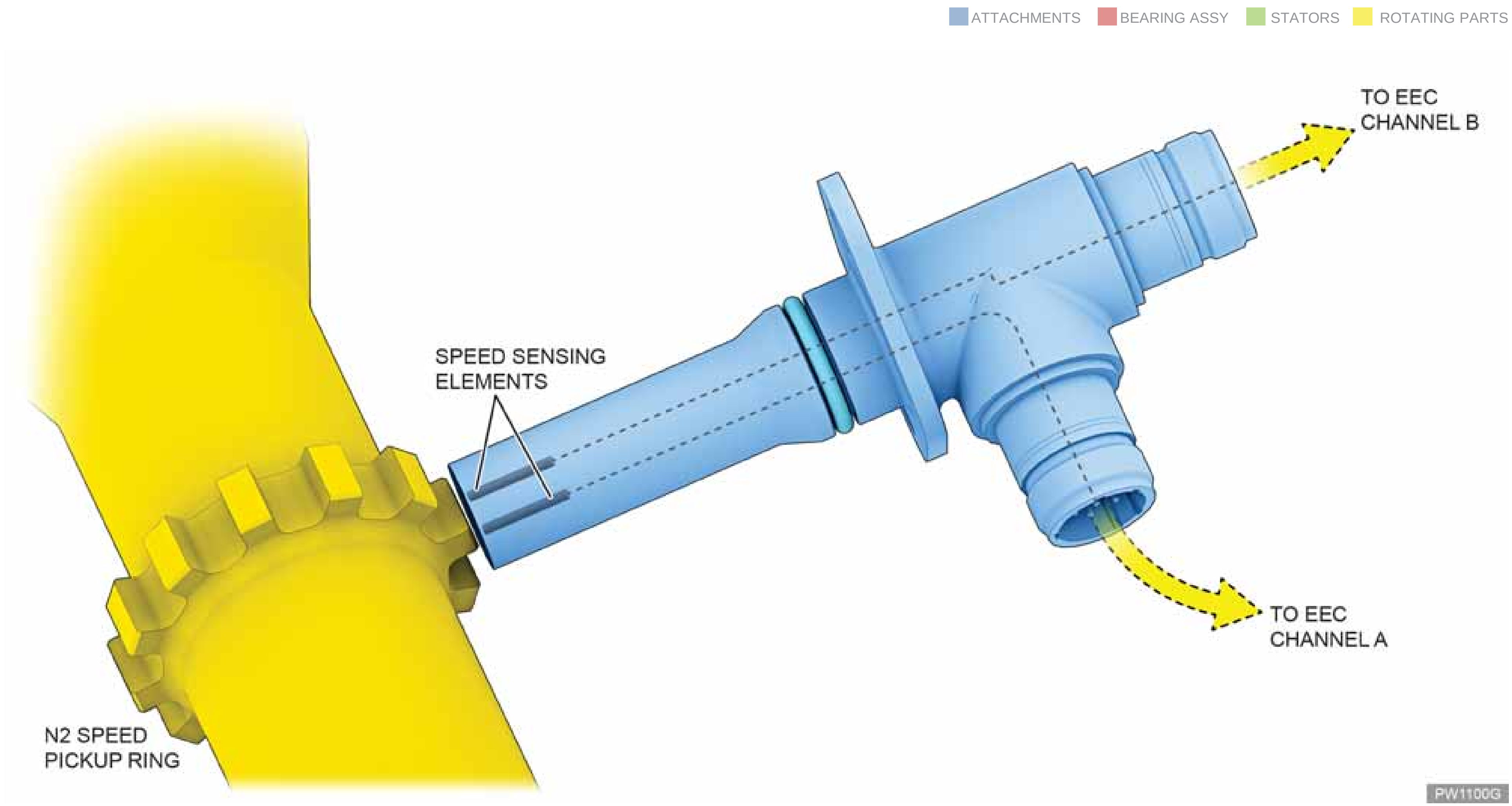
N2 Speed Sensor (Cont.)

Operation:

The tip of the probe is positioned adjacent to a 14-tooth pickup ring on the radial bevel gear shaft in the Angle Gearbox. The N2 speed sensor detects high rotor shaft speed by sensing each tooth as it passes the tip of the magnetic probe.

As the teeth of the radial bevel gear shaft pass by the face of the magnet, a change occurs in the magnetic field, creating a time-varying electrical pulse signal. The signal is transmitted to both the EEC and PHMU and converted to a rotational speed. The rotational speed is then sent to the Engine Interface Unit (EIU) for display on the flight deck.

If the N2 speed signal from both channels is lost during engine operation, an ECAM warning displays on the flight deck to indicate that the N2 speed sensor has failed.



POWER INDICATING SYSTEM – N2 SPEED SENSOR (2 OF 2)

POWER INDICATING SYSTEM (Cont.)

Nf Speed Sensor

Purpose:

LRU PMT

The Nf speed sensor senses and transmits fan rotor (Nf) speed to the EEC.

Location:

The sensor is mounted at 1:00 to the support for bearing nos. 1 and 1.5, and is internal to the engine.

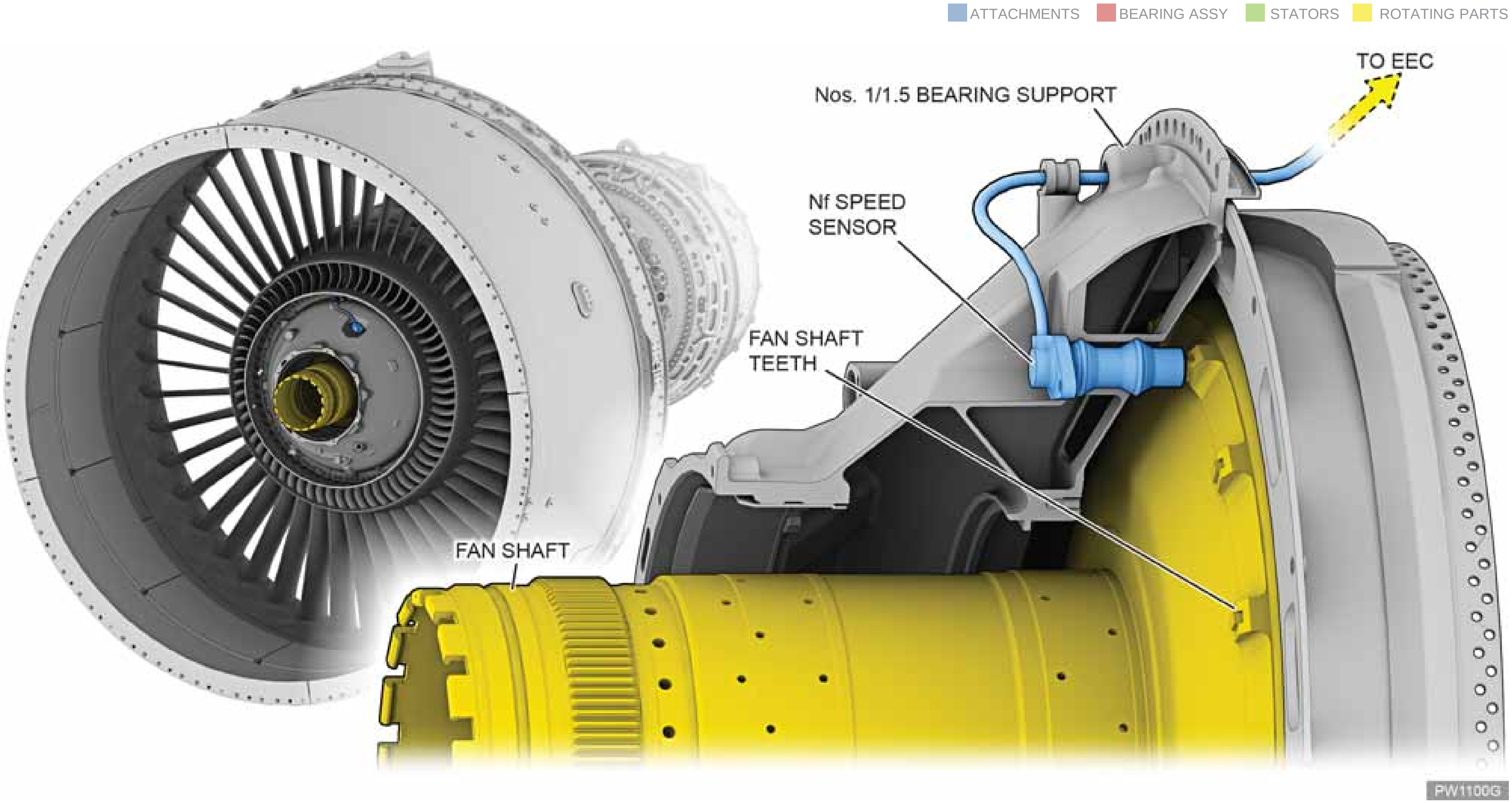
Description:

The probe is a single-channel sensor with a two-bolt mounting flange, a single magnet coil and an electrical connector.

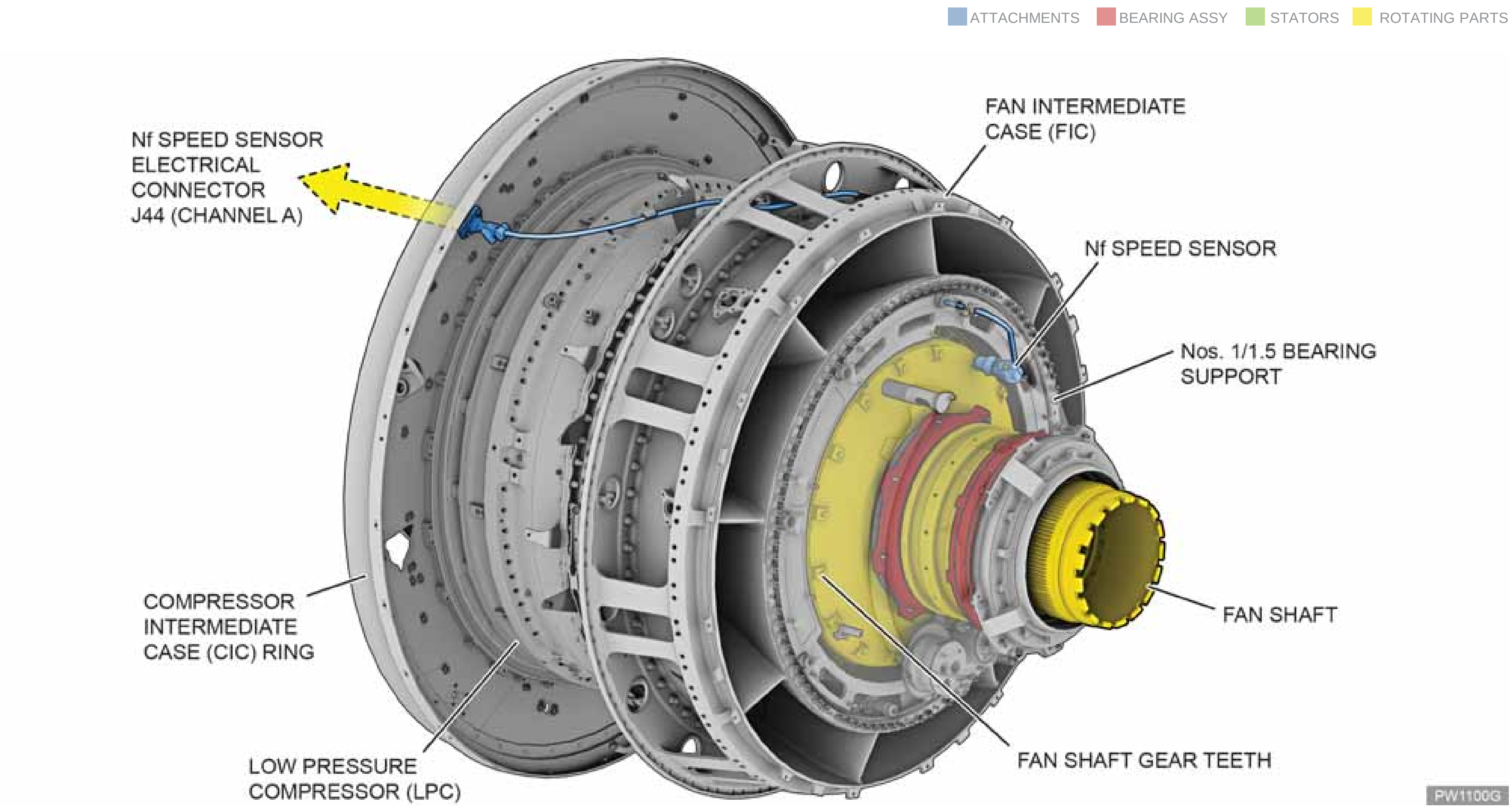
The probe has two O-rings on the sensor body for preventing oil leaks from the front bearing compartment.

The Nf speed sensor includes an electrical harness and connector that are replaced with the probe as one unit. The harness connects with the FADEC harnesses at the fire containment ring of the Compressor Intermediate Case (CIC).

Removal of the sensor requires extraction of the connector pins using the pin extractor tool.



POWER INDICATING SYSTEM – Nf SPEED SENSOR (1 OF 3)



POWER INDICATING SYSTEM – Nf SPEED SENSOR (2 OF 3)

POWER INDICATING SYSTEM

Nf Speed Sensor (Cont.)

Operation:

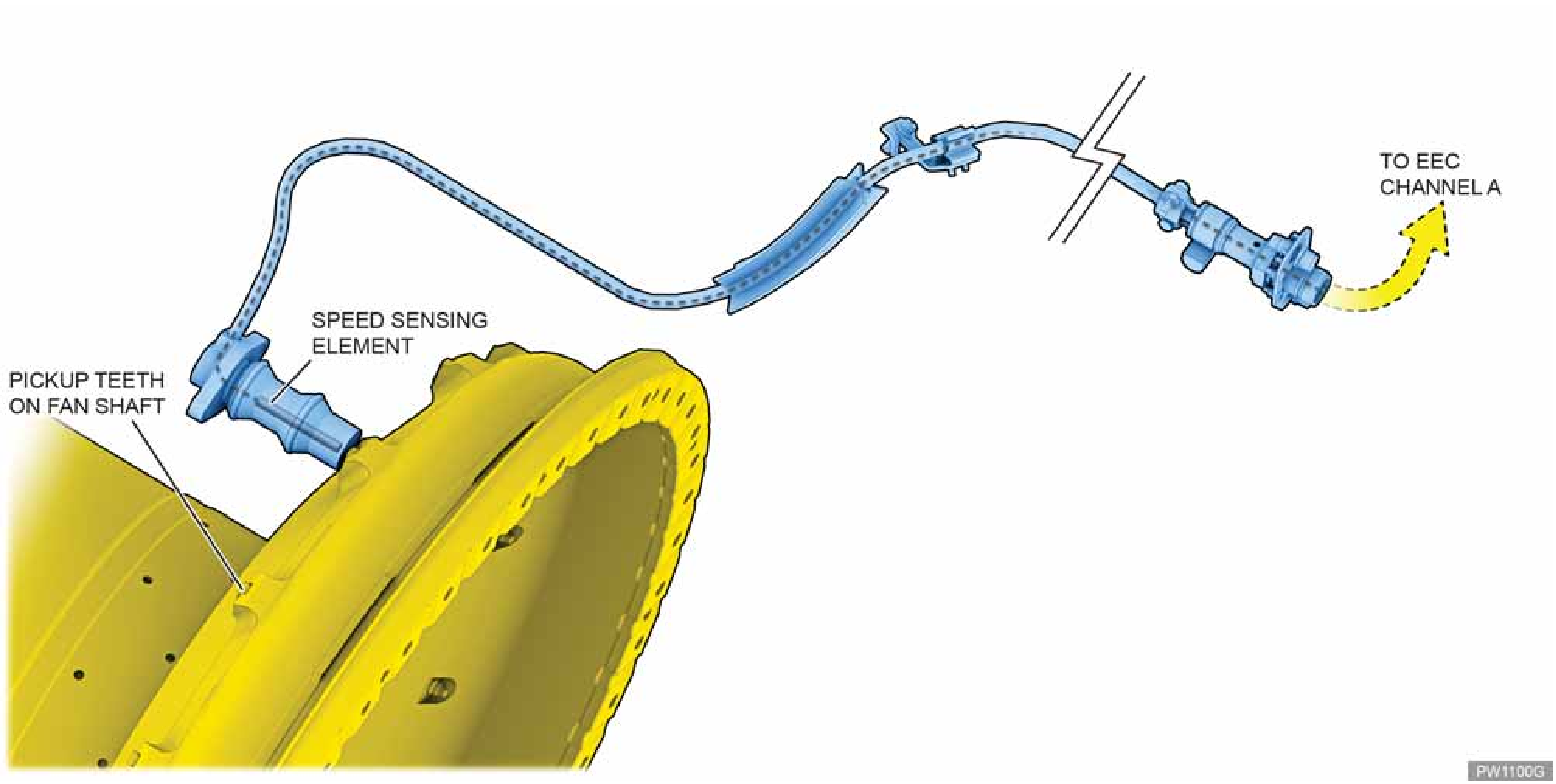
The sensor sends an Nf speed signal through the EEC to the PHMU, where it is used with the N1 vibration sensor to measure fan vibration. The speed signal and vibration data are used for on-wing trim balancing. The Nf speed signal is not displayed on the flight deck.

The tip of the Nf speed sensor is positioned adjacent to 16 teeth attached to the fan shaft. The sensor gauges fan rotor shaft speed by detecting each tooth as it passes the tip of the magnetic probe. As the teeth attached to the fan shaft pass by the face of the magnet, a change occurs in the magnetic field, creating a time-varying electrical pulse signal. The signal is then transmitted to the EEC and PHMU, and converted to a rotational speed.

Two of the fan shaft teeth, a short tooth and an offset tooth, are used together to determine fan shaft clocking for balancing.

The EEC compares the fan speed indication to the N1 speed to detect decoupling of the fan shaft. The PHMU uses fan speed in conjunction with fan rotor vibration to calculate trim balance solutions for maintenance purposes.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



POWER INDICATING SYSTEM – Nf SPEED SENSOR (3 OF 3)

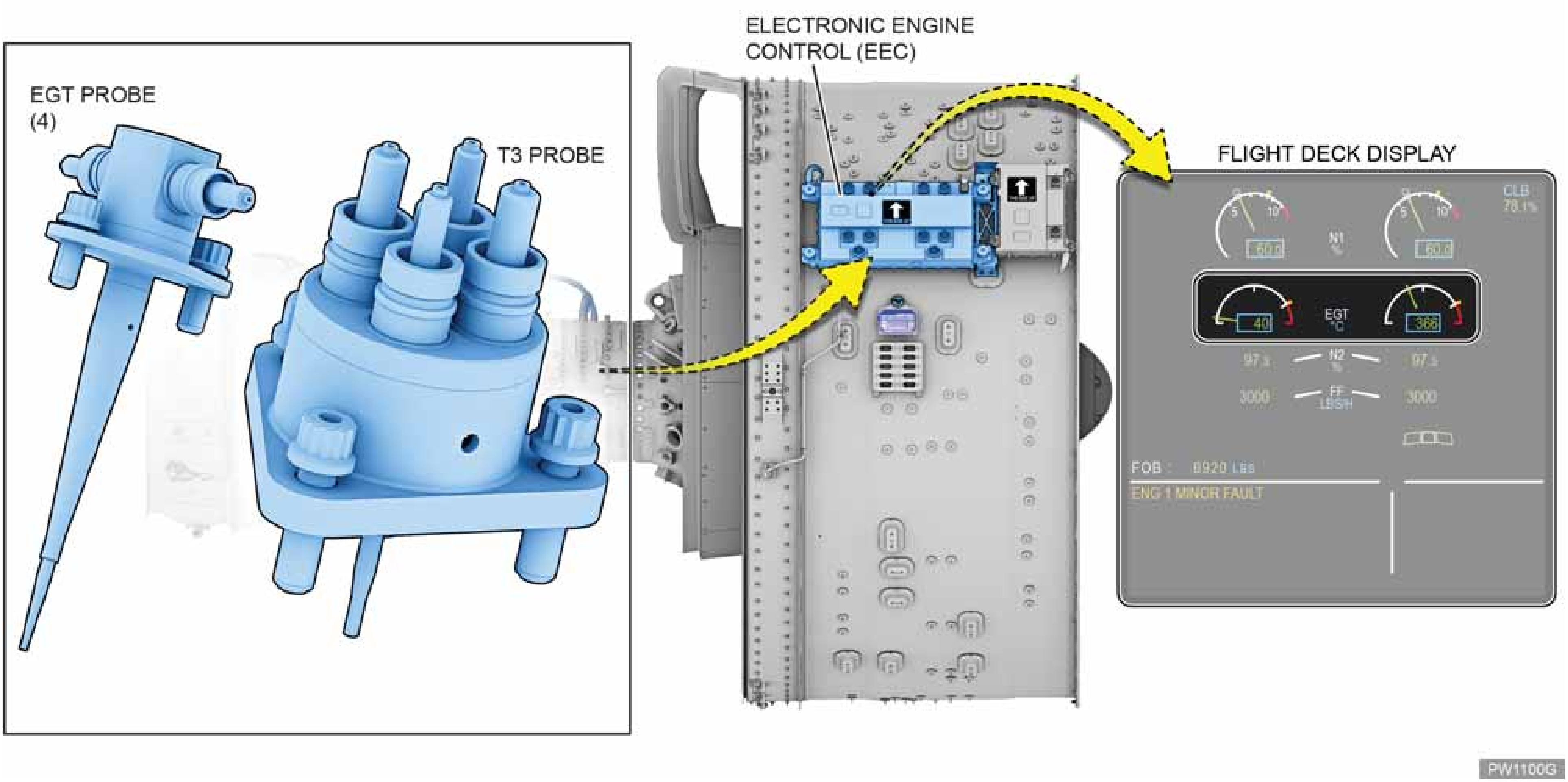
TEMPERATURE INDICATING SYSTEM

The Temperature Indicating System uses four Exhaust Gas Temperature (EGT) sensors to detect EGT and send the information to the Electronic Engine Control (EEC). The system also uses a single probe to measure the temperature of HPC discharge air at Station 3 for compressor performance analysis.

The four EGT sensors, known as T5 sensors, measure gaspath operating temperatures at the Turbine Exhaust Case (TEC) and are positioned at semi-regular intervals around its circumference. Each of two arrays has two active sensors and each array is called an EGT sensor and cable assembly. The two arrays are connected to the WC05 harness.

The EEC processes the EGT signal and uses it to compute Inter-Turbine Temperature (ITT)), which is a more accurate indicator of engine distress. The ITT value is indicated on the ECAM as EGT.

The single probe measuring the temperature of HPC discharge air is known as the T3 probe. Its information is communicated to the EEC but is not indicated on the flight deck. The probe is mounted at approximately 1:00.



TEMPERATURE INDICATING SYSTEM (1 OF 2)

TEMPERATURE INDICATING SYSTEM (Cont.)

EGT (T5) Sensor and Cable Assembly – Right and Left Sides

Purpose:

LRU PMT

Four EGT (T5) sensors detect gaspath temperatures for hot start protection, light-off detection, and engine health monitoring, then transmit the temperature signal to Electronic Engine Control.

Location:

T5 sensors are positioned around the circumference of the Turbine Exhaust Case (TEC) at semi-regular intervals at 2:00, 4:00, 8:00 and 10:00.

Description:

Each sensor is a single-channel, Chromel®/Alumel® thermocouple probe that detects gaspath temperature at the exit of the Low Pressure Turbine. The sensor consists of a Type K thermocouple element that is covered by an insulated metal sheath. The sheath is covered by the element support, with the exception of a short length near the tip where EGT is to be measured.

Safety Conditions

WARNING

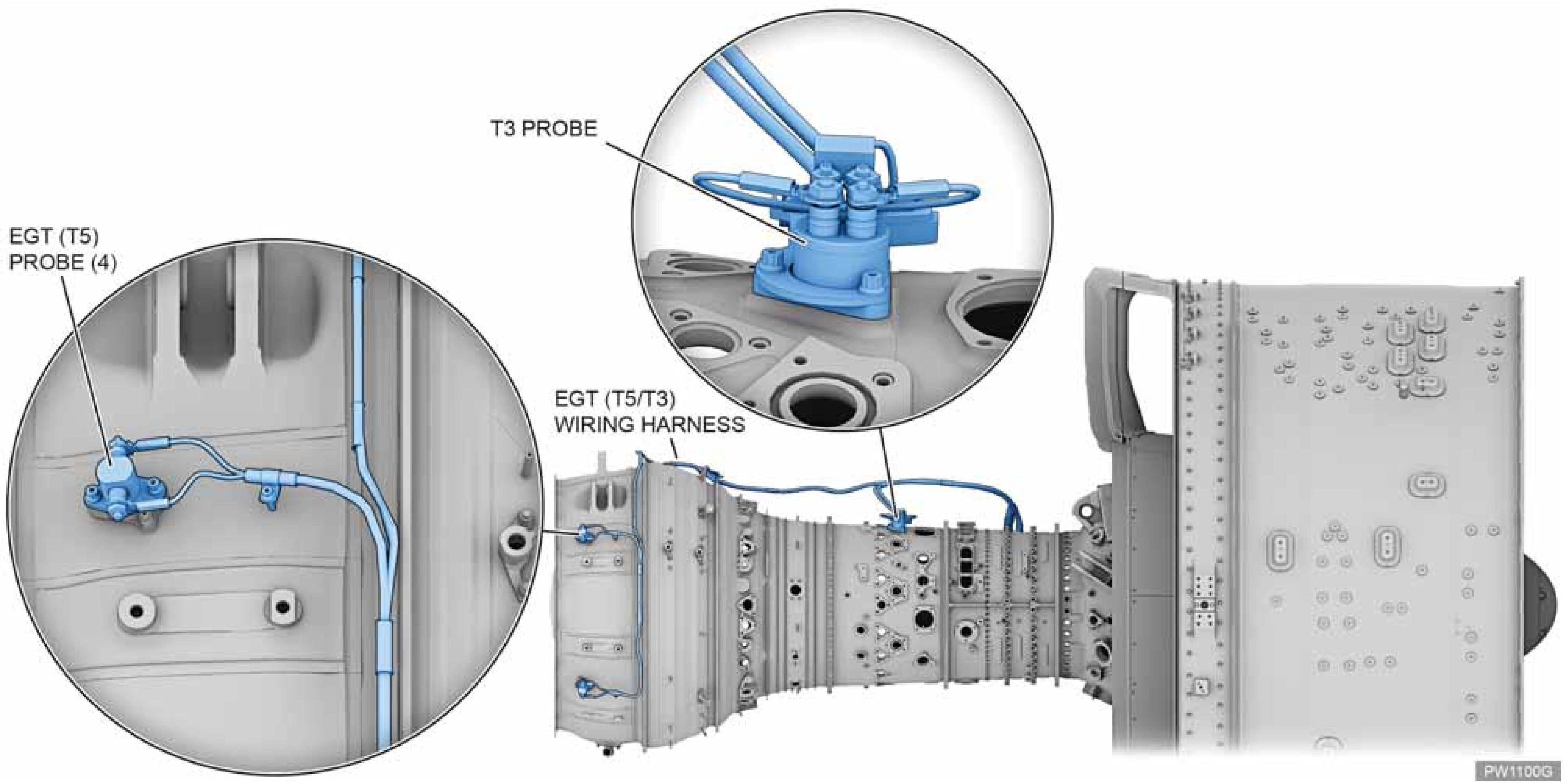
WAIT 5 MINUTES MINIMUM TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE DOING THIS PROCEDURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

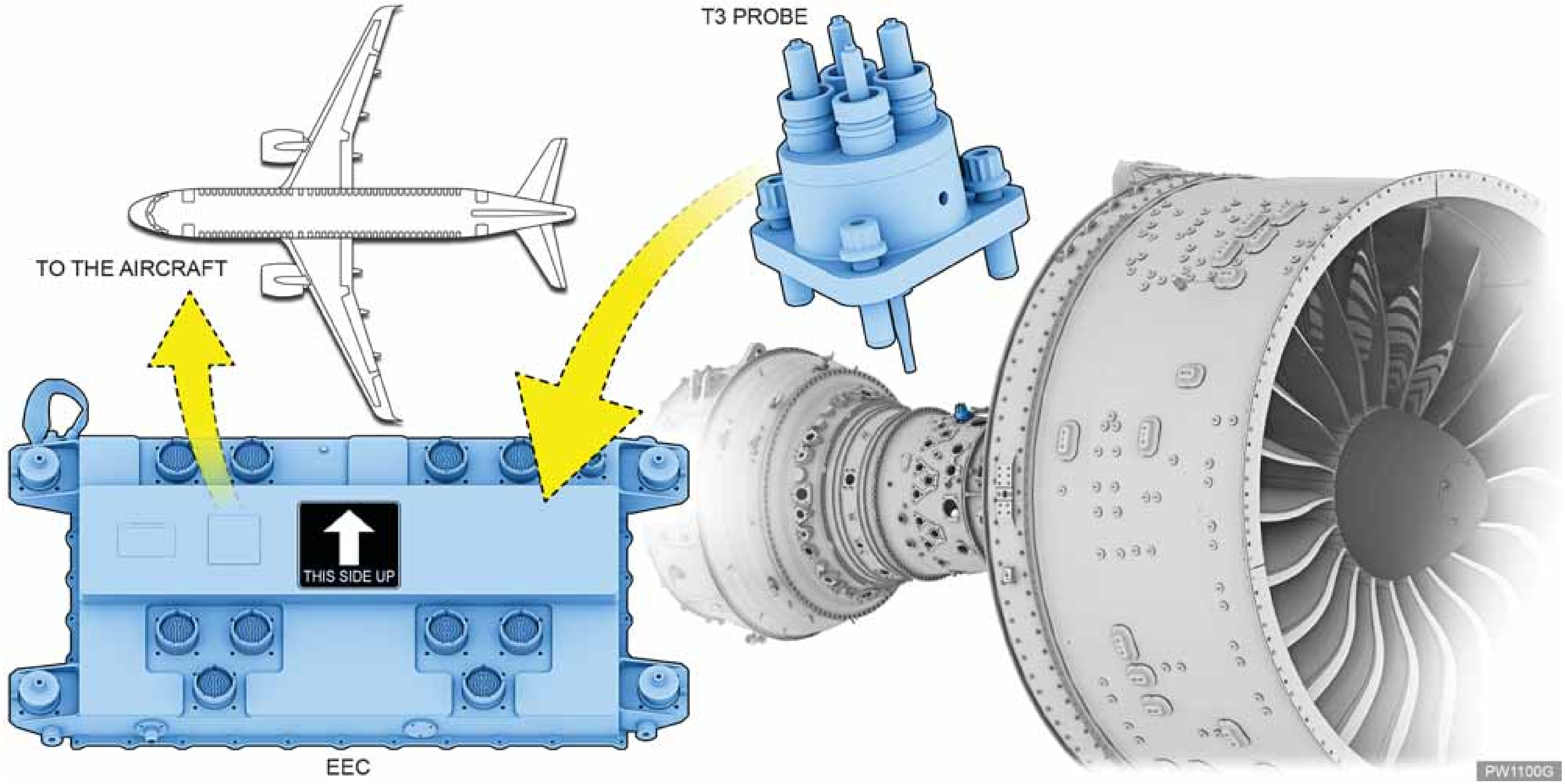
DO NOT TORQUE THE STUD NUTS MORE THAN THE SPECIFIED TORQUE. IF YOU DO, YOU CAN DAMAGE OR BREAK THE STUDS.

The element support is welded to the mount flange/terminal assembly, holding the metal sheath and also limiting its exposure to the engine gaspath airflow.

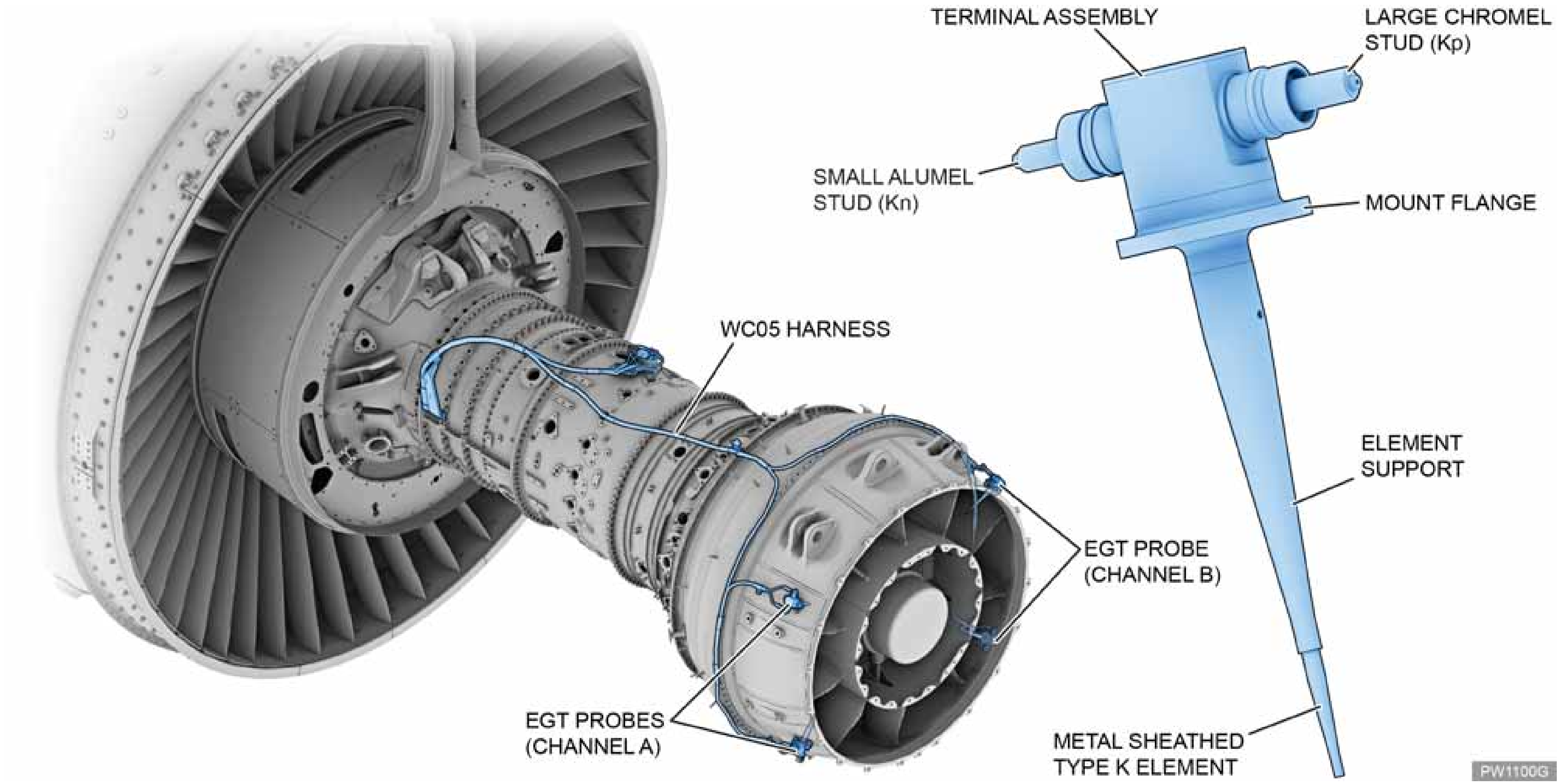
Thermocouple wires are potted with aluminum-silica material within the terminal assembly. The studs are insulated from the body by ceramic spacers which eliminate the possibility of a secondary junction.



TEMPERATURE INDICATING SYSTEM (2 OF 2)



TEMPERATURE INDICATING SYSTEM – T3 PROBE



TEMPERATURE INDICATING SYSTEM – EGT PROBE

TEMPERATURE INDICATING SYSTEM

EGT (T5) Sensor And Cable Assembly – Right and Left Sides (Cont.)

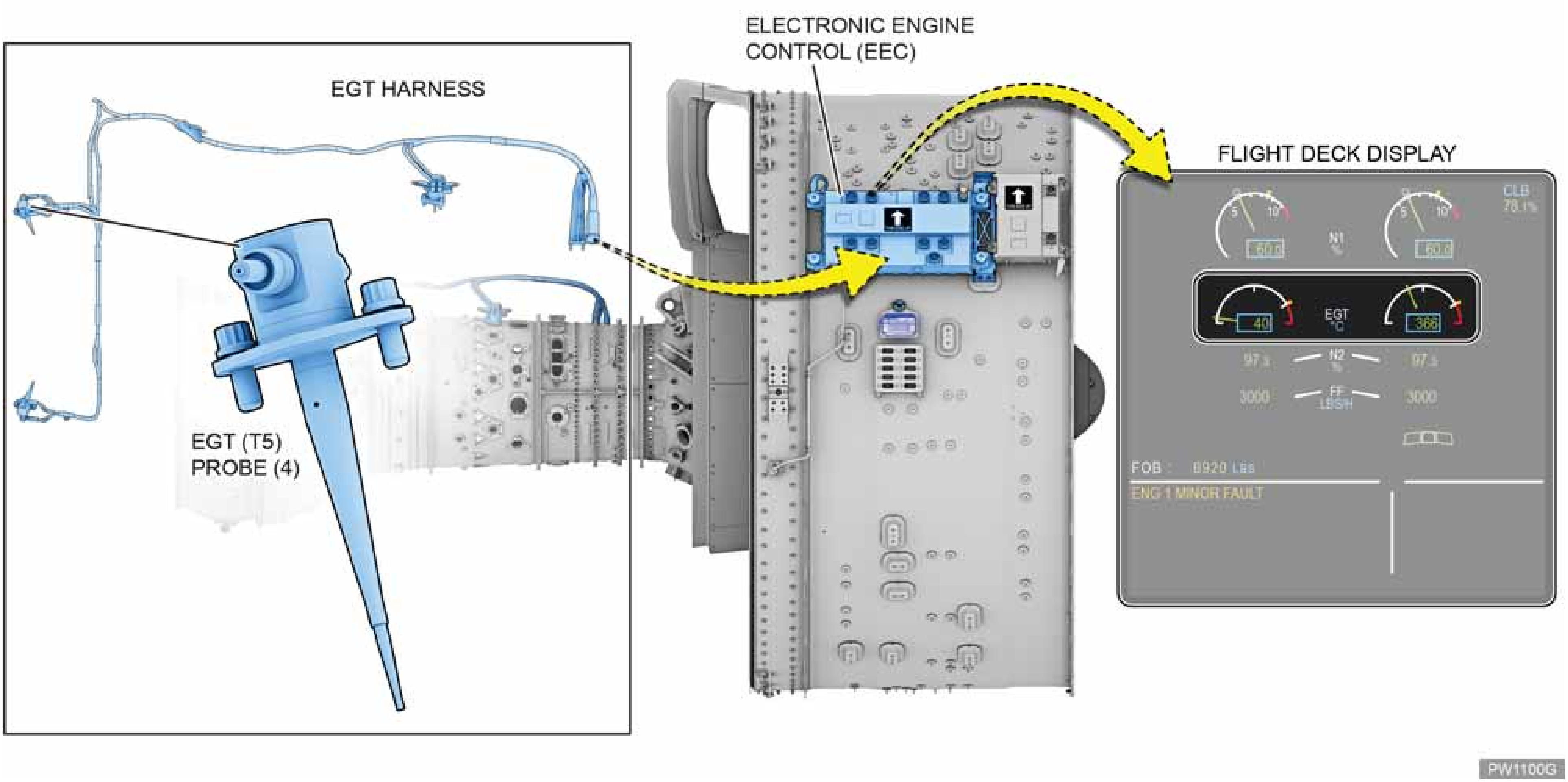
Operation:

1. Signals from the four probes are electrically averaged and sent to the EEC through the WC05 harness. The two signals from the left side are averaged into the Channel A signal and the two signals from the right side are averaged into the Channel B signal.

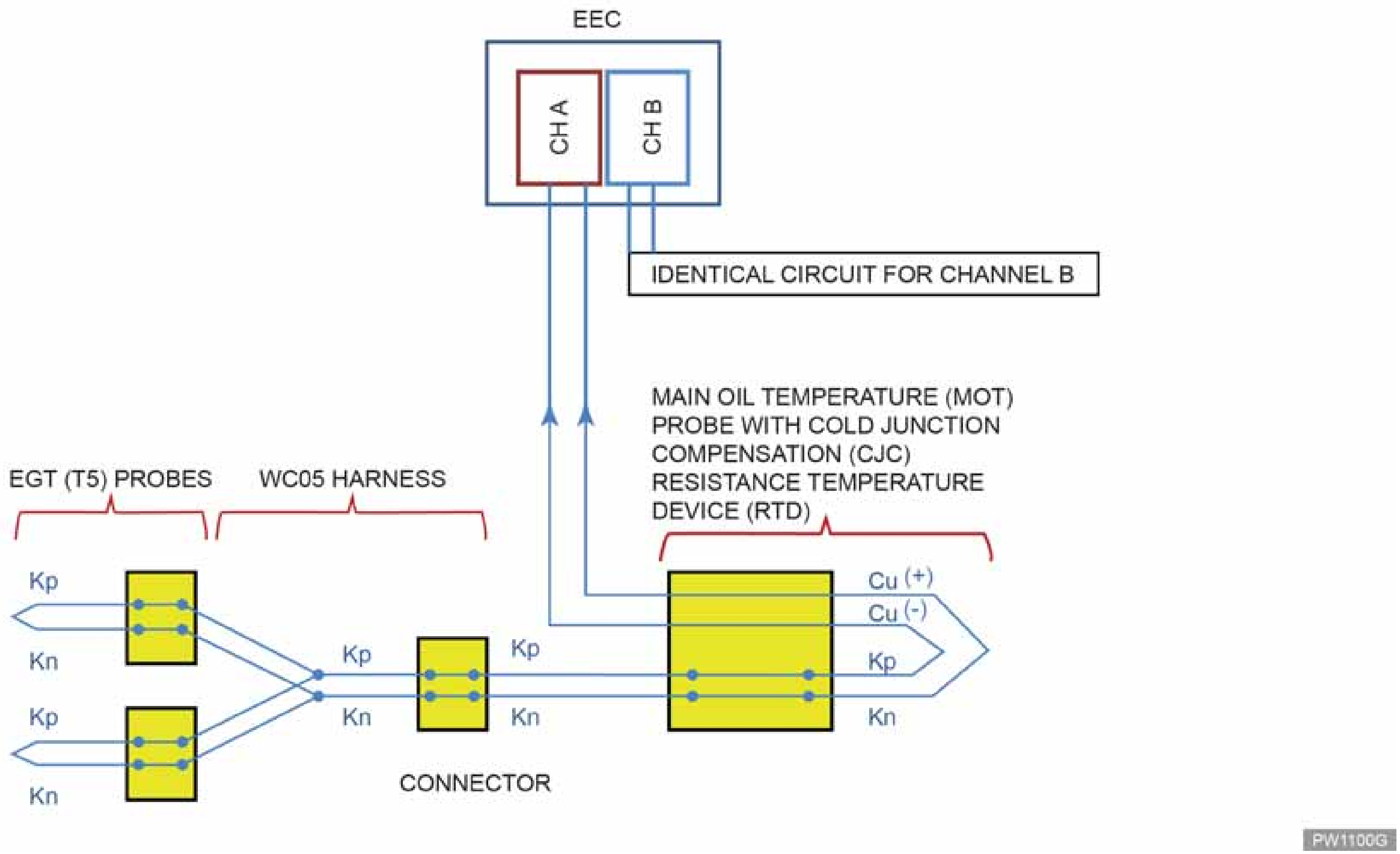
2. The Cold Junction Compensation (CJC) used by the EEC to compute Exhaust Gas Temperature is located at the Main Oil Temperature sensor. The WC05 harness assembly transmits the analog signals from the EGT probes to the EEC, which then computes the EGT in degrees C or F for channels A and B. The EEC converts the analog signal to a digital signal and then transmits the signal to the EIU.

3. EGT indication on the upper ECAM displays in analog form by means of a mark from 0–1200°C. EGT also displays in digital form with 4 digits from -99 to 2048, in 1° increments. Both analog and digital displays are green in color during normal engine operation.

The display changes from green to amber if the EGT value exceeds a second, higher predetermined value. If the computed EGT temperature is determined to be out of range for both channels A and B, the EGT digital display is replaced by amber crosses.



TEMPERATURE INDICATING SYSTEM OPERATION



TEMPERATURE INDICATING SYSTEM – EGT PROBE

ANALYZER SYSTEM

Overview

The Analyzer System monitors and processes critical information about engine oil debris, rotor vibration, fan trim balance solutions, Auxiliary Oil System pressure, and communicates this information to the EEC and the flight deck..

A primary component of this system is the Prognostics and Health Management Unit (PHMU).

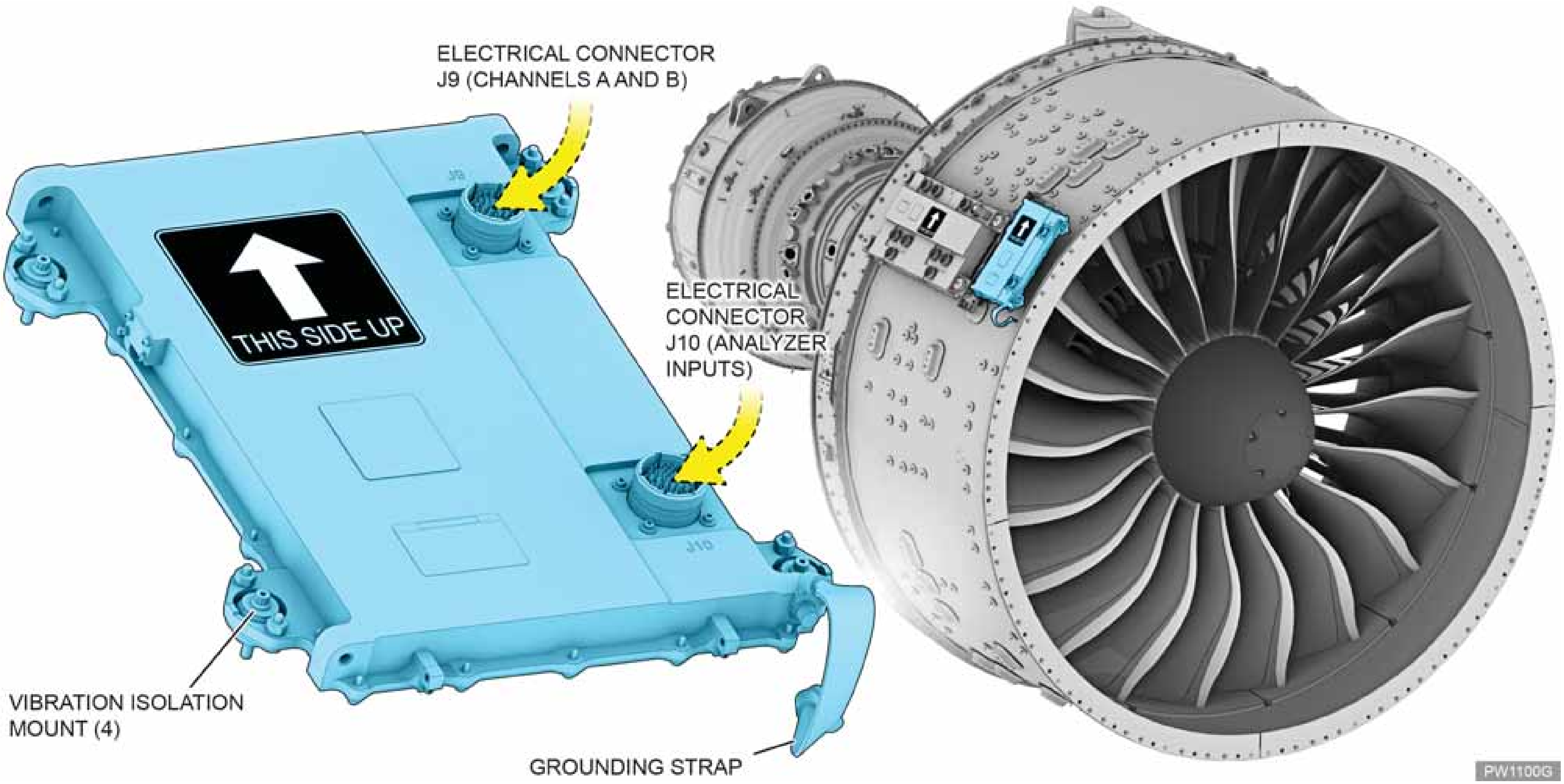
The PHMU continuously computes engine trim balance solutions using Nf, N1, and N2 speed signals received from the EEC, and from the vibration signals received from the aft and forward vibration sensors. This information is stored by the PHMU in the Data Storage Unit (DSU).

A trim balance procedure in the flight deck interprets the stored data using the interactive mode, and provides instructions to trim balance the fan.

The chart shows the Analyzer subsystems and the PHMU functions for each one.

Capabilities	Function
Oil debris monitoring	• Provides early indication of ferrous and non-ferrous particles in engine oil, based on data from the Oil Debris Monitor • Detects and annunciates exceedances based on the rate of particle generation over a period of time
Vibration monitoring	• Analyzes data from engine vibration sensors, plus N1, N2, and Nf inputs from the EEC. Combined data provides flight deck indication as well as detection and annunciation of vibration exceedances • Calculates optimum fan trim balance solutions using flight or ground data
Auxiliary oil pressure monitoring	• Performs analog-to-digital conversion of signals from the AOPS, sending the digital signals to the EEC
Trim balance	• The PHMU continuously computes engine trim balance solutions using Nf, N1, and N2 speed signals received from the EEC, and from the vibration signals received from the aft and forward accelerometers. This information is stored by the PHMU in the DSU.

ANALYZER SYSTEM – PHMU CAPABILITIES



ANALYZER SYSTEM OPERATION

ANALYZER SYSTEM (Cont.)

Prognostics and Health Management Unit (PHMU)

Purpose: LRU PMT

The Prognostics and Health Management Unit monitors and processes levels for engine oil debris and rotor vibration. It also calculates fan trim balance solutions and Auxiliary Lubrication System oil pressure.

Location:

The PHMU is mounted on the fan case at 2:00 forward of the EEC.

Description:

The PHMU is a vibration-isolated, convection air-cooled unit weighing 6.3 lbs and powered by aircraft 28V DC. Its single-channel unit contains a processor and has two connectors, J9 and J10.

The PHMU monitors itself for internal faults and overall health, and checks components and functions shown in the following list.

- Auxiliary Oil Pressure Sensor AOPS
- N1, N2, and Nf Vibration monitoring
- Oil Debris Monitor ODM
- Wiring between EEC and PHMU

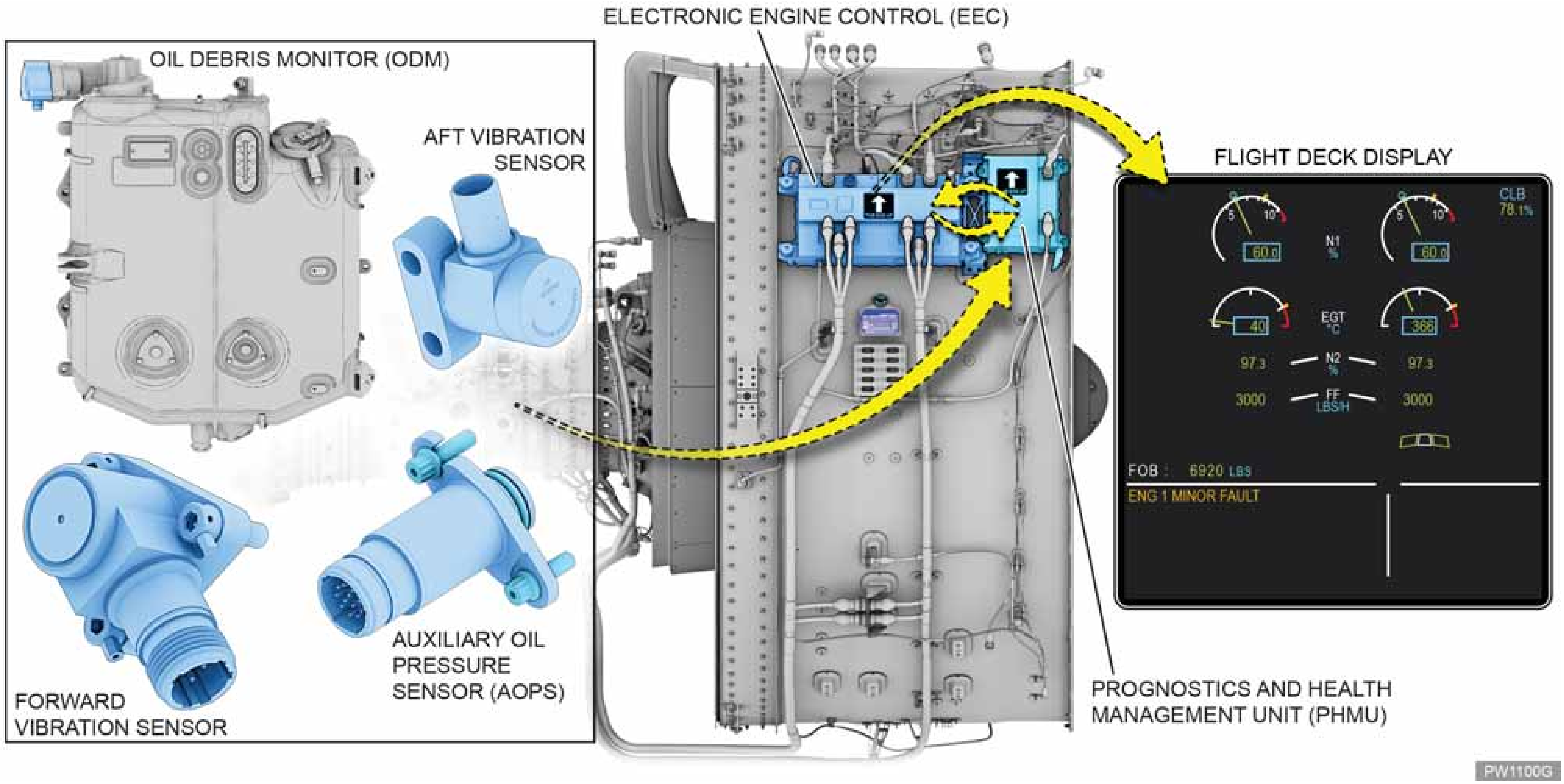
Operation:

The PHMU receives signals from the Oil Debris Monitor (ODM), forward and aft engine vibration sensors, and the Auxiliary Oil Pressure Sensor (AOPS), and sends the processed output signals to the EEC. The EEC sends PHMU data to the Data Storage Unit (DSU).

The PHMU communicates with the EEC via a Control Area Network (CAN) data bus and uses one bus per EEC channel. The PHMU is re-programmable on-wing either from the flight deck or via use of a Common Engine Software Loader.

KEY FACT

The PHMU reduces maintenance needs by accurately predicting low and high rotor issues, as well as Lubrication System problems.



ANALYZER SYSTEM – PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU) OPERATION

ANALYZER SYSTEM

Prognostics and Health Management Unit (PHMU)

Operation (Cont.):

The PHMU has two connectors, J9 and J10, whose inputs and outputs are shown in the chart.

Normal and Interactive Modes

The PHMU operates in one of two modes, normal or interactive.

In normal mode, the PHMU monitors the sensors, the CAN bus input, and performs health prognostic functions. Additionally, in this mode the PHMU performs vibration monitoring, oil debris monitoring, and enhanced fault detection.

In interactive mode, the PHMU responds to requests from the avionics system that are received through the EEC.

These functions are performed by monitoring and processing data from several analog inputs. This is supported by CAN and Ethernet communications.

Connector	Inputs and Outputs
J9	• Rotor speed signals • EEC communications • Test bus commands • D/C power from the aircraft
J10	• Accelerometer signals • Data from Oil Debris Monitor • AOPS signal

ANALYZER SYSTEM (Cont.)

Vibration Monitoring System

The Vibration Monitoring System analyzes vibration frequency signals from the fan (Nf), low rotor (N1), and high rotor (N2) for system display on the flight deck if predetermined vibration limits are exceeded.

The Vibration Monitoring System consists of aft and forward vibration sensors, the PHMU, and the EEC. Proportional electrical signals are sent from the vibration sensors to the PHMU on the fan case next to the EEC.

The PHMU converts the signals to a voltage, filters them, and correlates the frequencies with a specific rotor. The fan, N1, and N2 vibration signals are then sent to the EEC. The EEC transmits this data to the flight deck's system display.

If all three calculated vibration levels (low pressure rotor, high pressure rotor, and fan) are within normal range, no vibration display appears in the flight deck. If the PHMU determines that any level exceeds normal range, the highest vibration level among the three is displayed for each engine.

Safety Conditions

CAUTION

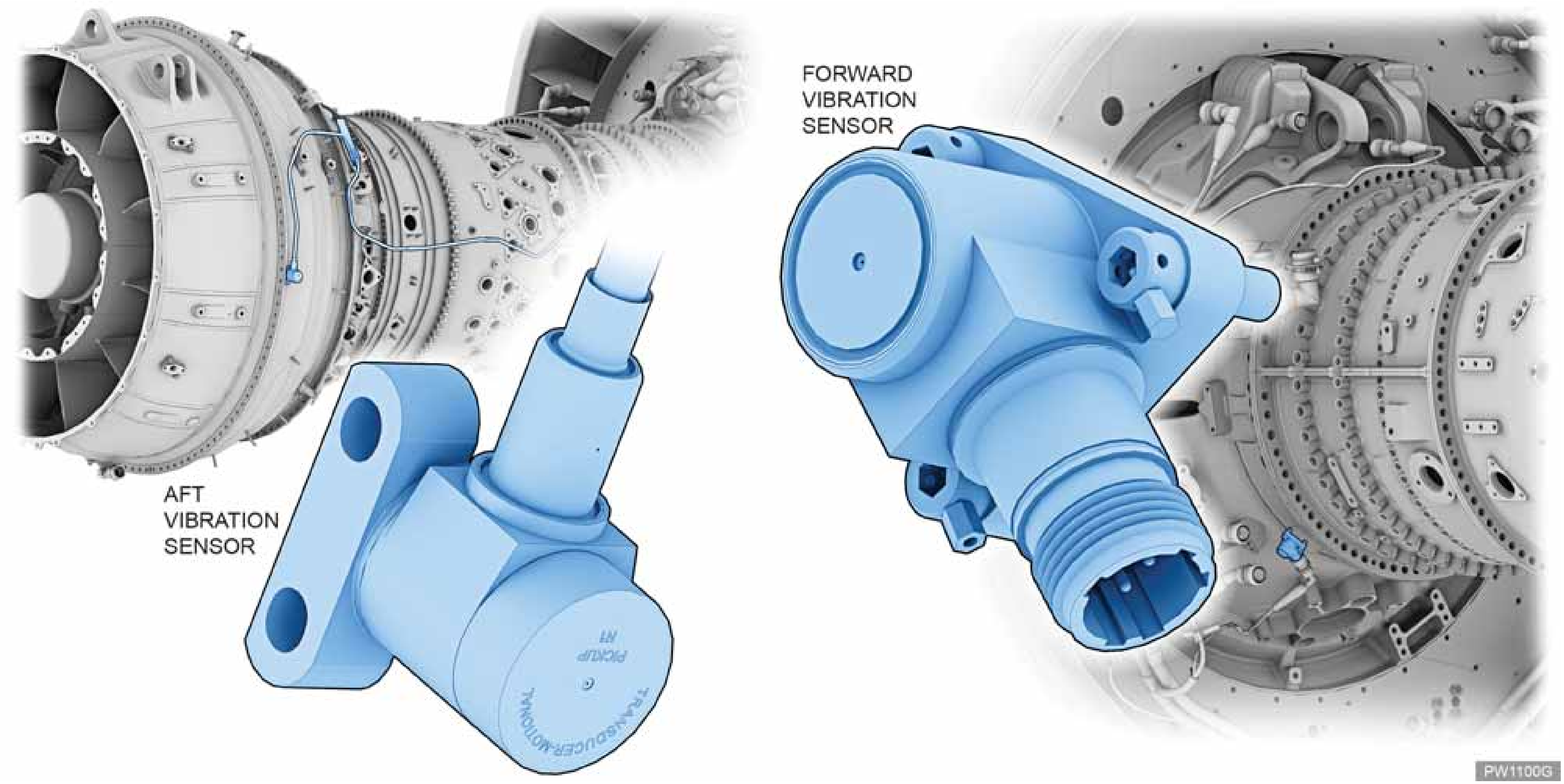
MAKE SURE THAT THE N2 VIBRATION SENSOR CABLE DOES NOT TOUCH SHARP-EDGE SURFACES, FUEL LINES, OIL LINES, HIGH PRESSURE PNEUMATIC DUCTS, PNUEMATIC SENSOR LINES, OR FABRIC BELLOWS.

MAKE SURE THAT THE N2 VIBRATION SENSOR CABLE DOES NOT HAVE ANY KINKS. IF YOU DO NOT FOLLOW THIS INSTRUCTION YOU COULD DAMAGE THE N2 VIBRATION SENSOR CABLE.

Two vibration levels are indicated on the ECAM, as shown in the table.

ECAM Indication	Source
N1 VIB	Fan vibration (Nf shaft vibration)
N2 VIB	Core vibration (max of N1 and N2 shaft vibrations

N1 VIB and N2 VIB are displayed as scaled units on the ECAM. The range of N1 VIB and N2 VIB is from 0.0 to 10.0 cockpit units (CU). N1 VIB and N2 VIB levels of 5.0 CU or higher are displayed in amber. Vibration levels below 5.0 are displayed in green.



ANALYZER SYSTEM – VIBRATION MONITORING SYSTEM COMPONENTS

ANALYZER SYSTEM (Cont.)

Vibration Monitoring

The forward and aft vibration sensors detect engine vibration levels and send vibration signals to the PHMU. The PHMU processes the signals in four steps.

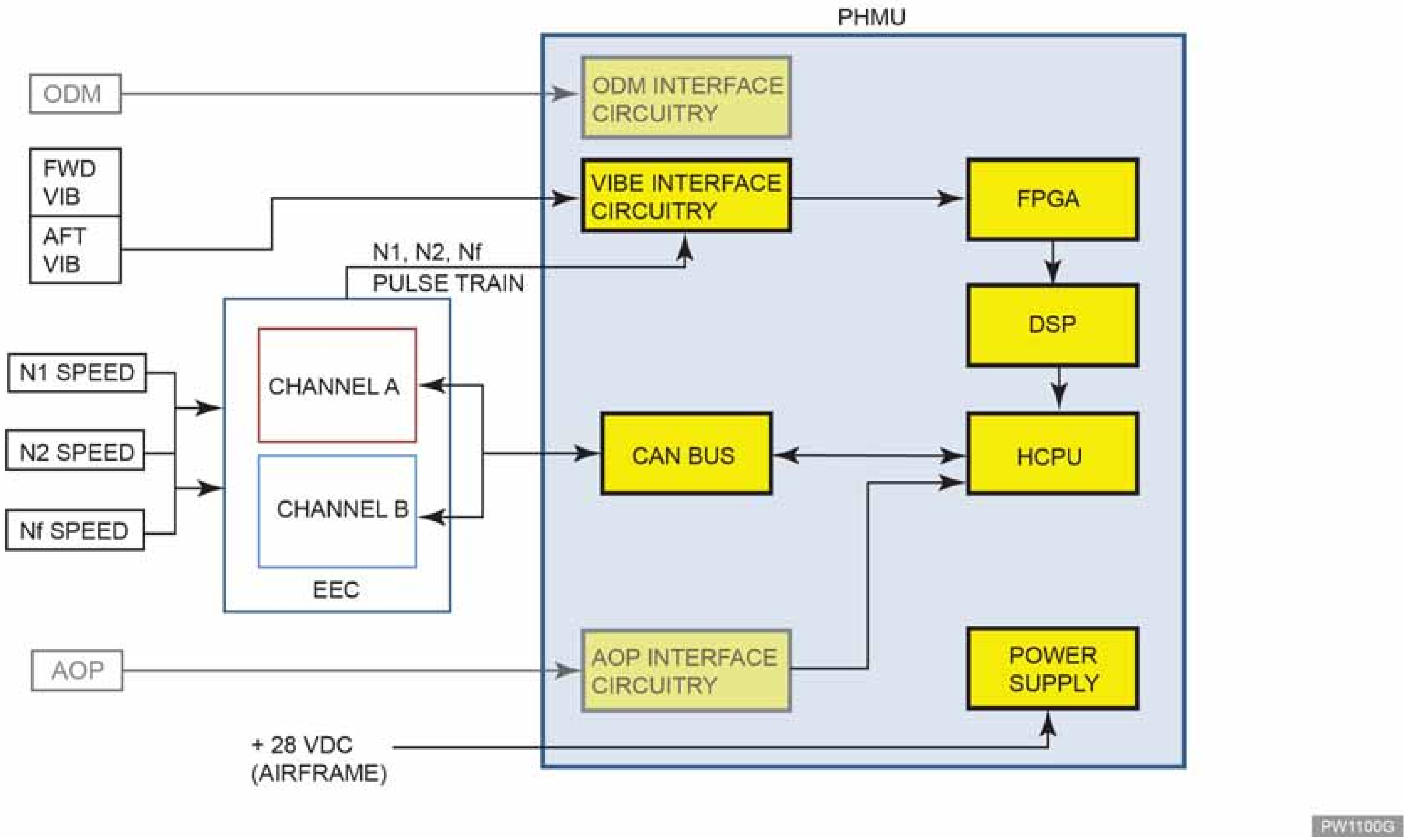
1. Within the PHMU, both the speed and vibration signals are filtered and converted from analog to digital format by the vibration interface circuitry.

2. The vibration signals are directed to the Field Programmable Gate Array (FPGA) concurrently with the Nf, N1, and N2 speed sensor signals. The FPGA calculates the Nf, N1, and N2 speeds coincident with the vibration data for synchronous analysis and sends the signal to the Digital Signal Processor (DSP).

3. Data is transformed to a frequency domain and sent to the Higher-level Central Processing Unit (HCPU).

4. The HCPU performs the following functions:

   - calculates frequency domain vibration information
   - detects exceedance conditions
   - scales the signals from engineering units to flight deck display units
   - performs trim balance functions
   - detects vibration system faults and fault enunciation
   - supports engine heath monitoring functions based on vibration data.



ANALYZER SYSTEM – PHMU VIBRATION AND SIGNAL PROCESSING

ANALYZER SYSTEM (Cont.)

Forward Vibration Sensor

Purpose: LRU PMT

The forward vibration sensor measures fan- and core-related vibrations and communicates that information to the PHMU.

Location:

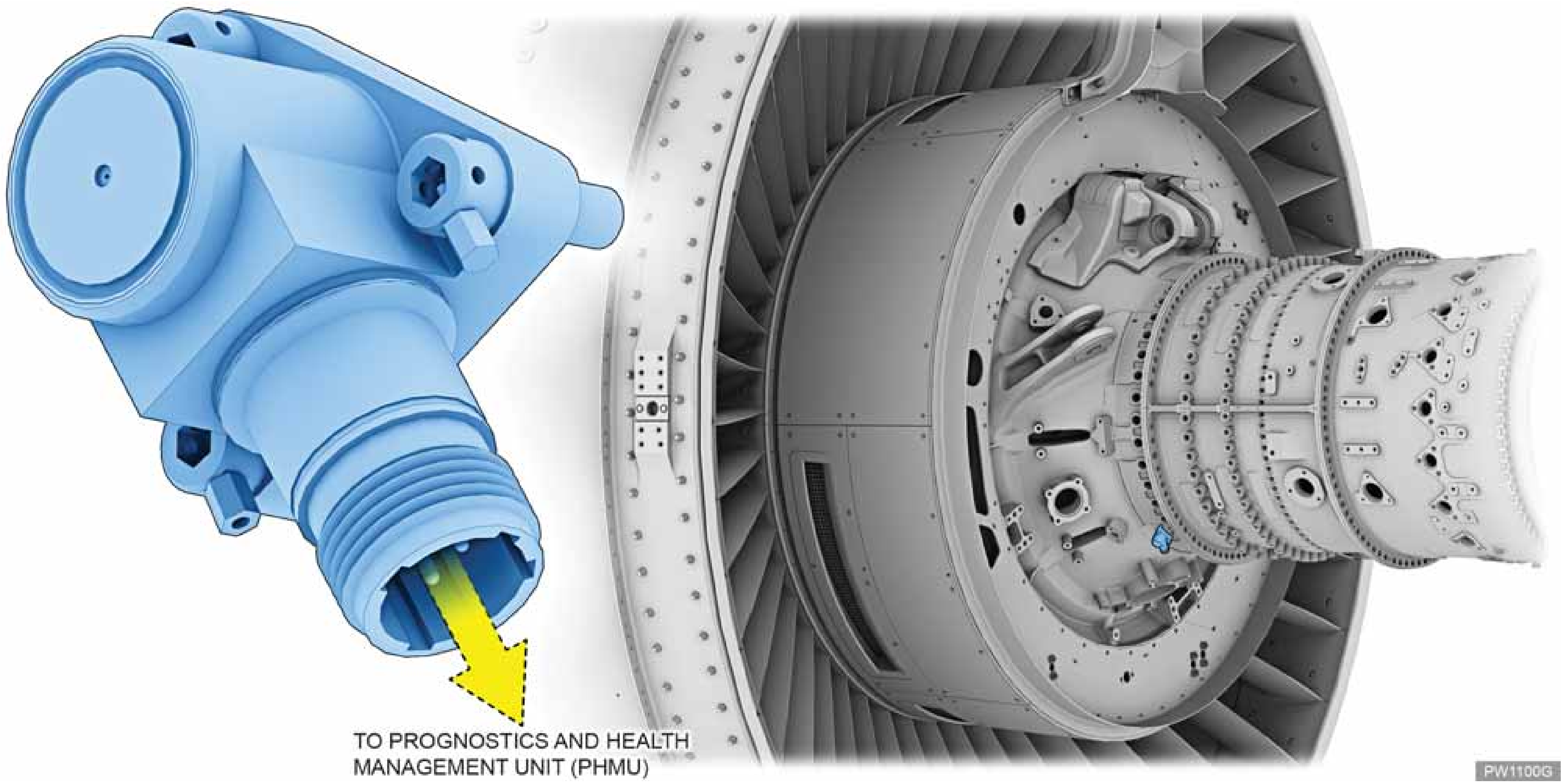
The sensor is externally mounted on the E Flange at 7:00.

Description:

The forward vibration sensor is a single-channel, piezoelectric accelerometer contained in a sealed body. The sensor is mounted to the CIC with two bolts and has an integral electrical connector.

Operation:

The sensor provides an electric output signal proportional to the acceleration it is subjected to. If the sensor fails, its flight deck display is replaced with amber crosses.



ANALYZER SYSTEM – FORWARD VIBRATION SENSOR

ANALYZER SYSTEM (Cont.)

Aft Vibration Sensor

Purpose:

LRU PMT

The aft vibration sensor measures fan- and core-related vibrations and communicates that information to the EEC.

Location:

The sensor is mounted to P Flange on the LPT housing at 3:00.

Description:

The aft vibration sensor is a single channel, piezoelectric accelerometer contained in a sealed body. The sensor is mounted to the LPT housing with two bolts and has an integral hard line cable and electrical connector.

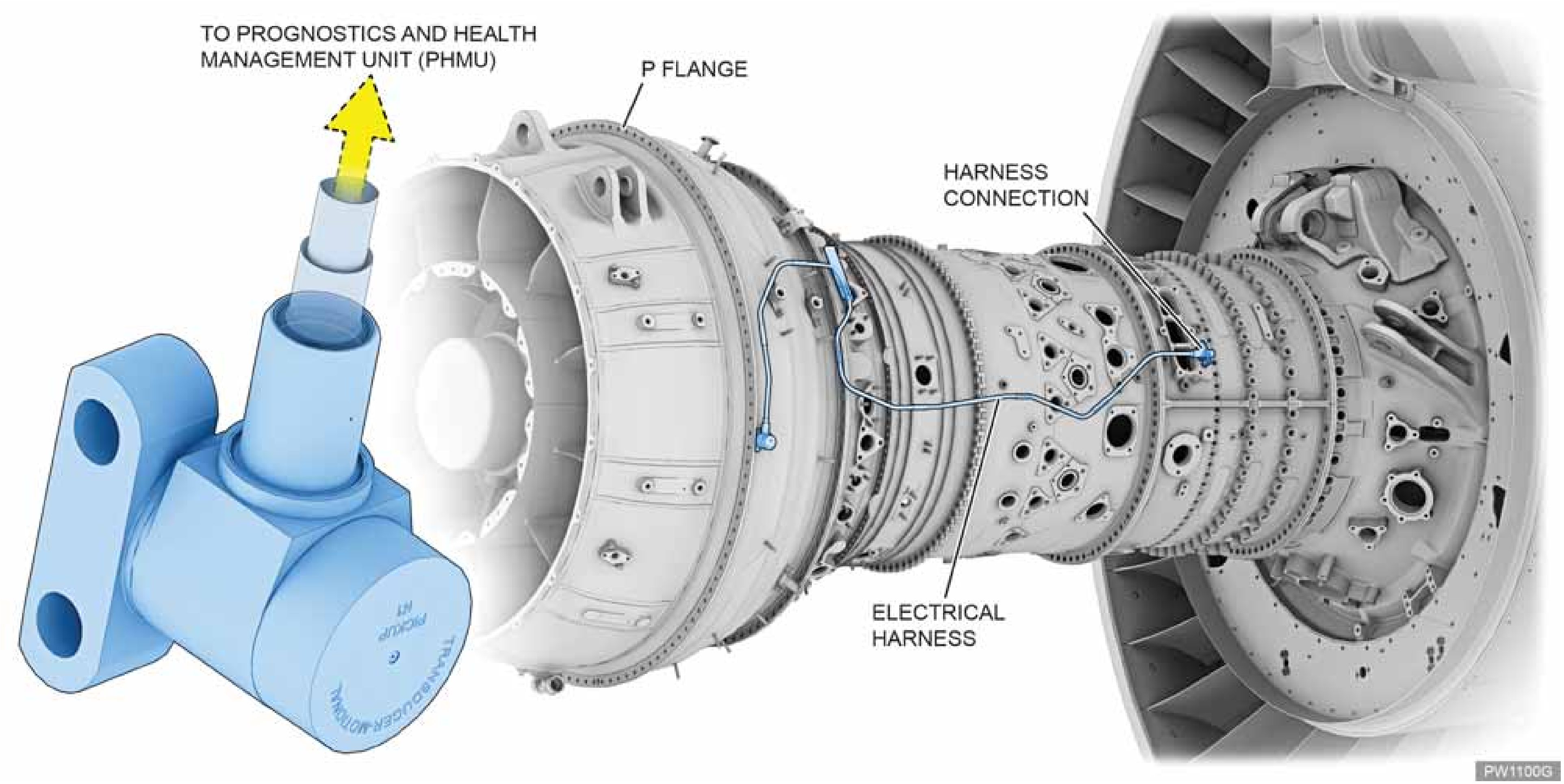
Operation:

The sensor provides an electric output signal proportional to the acceleration it is subjected to. If the sensor fails, its flight deck display is replaced with amber crosses.

Safety Conditions

CAUTION

MAKE SURE THAT THE AFT VIBRATION SENSOR CABLE DOES NOT TOUCH SHARP-EDGE SURFACES, FUEL LINES, OIL LINES, HIGH PRESSUMRE PNEUMATIC DUCTS, PNEUMATIC SENSOR LINES, OR FABRIC BELLOWS. MAKE SURE THAT THE AFT VIBRATION SENSOR CABLE DOES NOT HAVE ANY KINKS. IF YOU DO NOT FOLLOW THIS INSTRUCTION YOU COULD DAMAGE THE CABLE.



ANALYZER SYSTEM – AFT VIBRATION SENSOR

ANALYZER SYSTEM (Cont.)

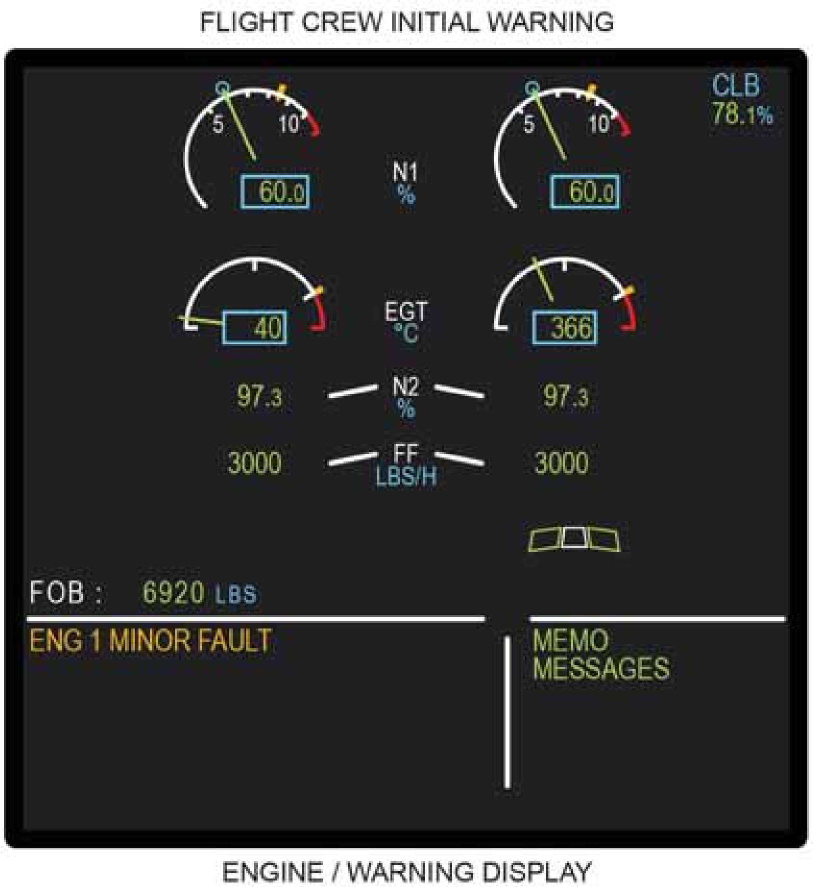
Vibration and Signal Processing

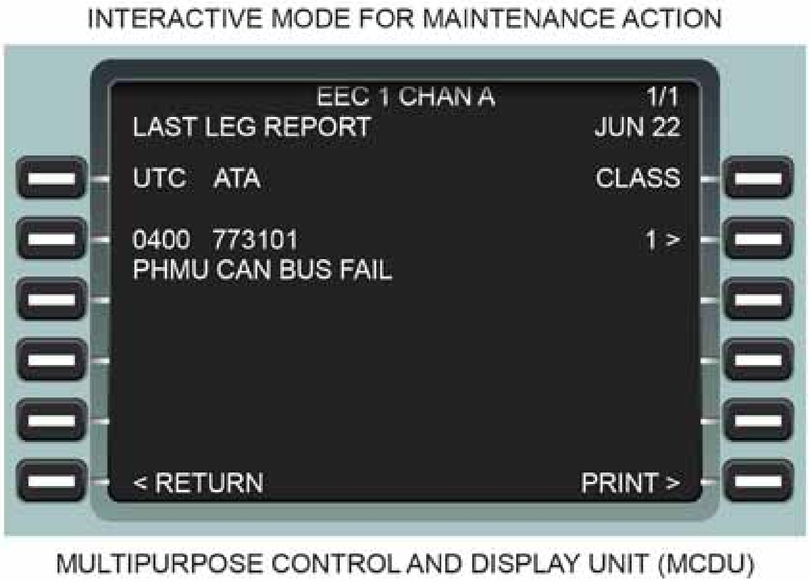
The Higher-level Central Processing Unit (HCPU) separates the processed vibration signals into three categories: fan vibration, high rotor vibration and low rotor vibration. The processed fan vibration signal is sent to the EEC as the N1 vibration signal. The largest processed high or low rotor vibration signal, referred to as the *core* vibration, is sent to the EEC as the N2 vibration signal.

The EEC sends the N1 and N2 signals to the EIU, which forwards the information to the flight deck for display on the engine page. Indications are displayed in digital form, using 3 digits from 0.0 to 10.0, with a step of 0.1 unit. An associated ECAM warning also appears.

Indications for N1 and N2 display as described in the chart.

Indication	Meaning
Steady green	Normal operation
Steady amber	Excessive vibration values





SAMPLE ECAM MESSAGE FOR ATA 77

ANALYZER SYSTEM

Vibration and Signal Processing (Cont.)

Trim Balance

The PHMU continuously computes engine trim balance solutions using Nf, N1, and N2 speed signals received from the EEC, and from the vibration signals received from the aft and forward accelerometers.

A trim balance procedure performed in the flight deck interprets the stored data using the interactive mode, and provides instructions to trim balance the fan.

The PHMU transmits the calculated result of the optimal trim balance solutions from flight or ground vibration data to the EEC for maintenance trim balances.

The Data Storage Unit (DSU) stores the trim balance solutions calculated by the PHMU while the engine is running. This assures the trim balance data stays with the engine if the PHMU is changed.

Stored data from the most recent 10 flights or ground runs enables the operator to review vibration trend data. If a fault is detected during the check, the PHMU will communicate the fault to the EEC, and the EEC will set the fault message.

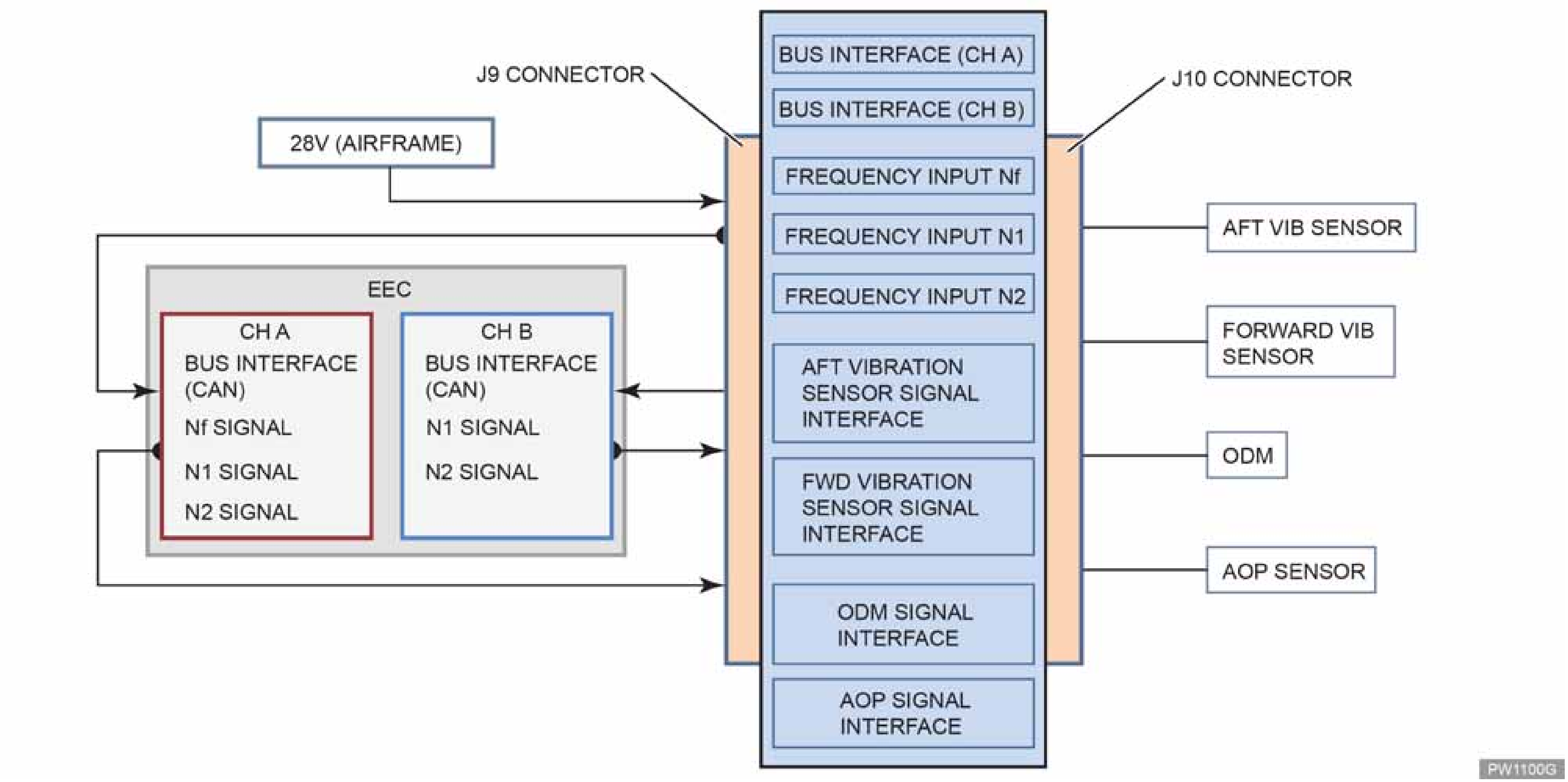
Safety Conditions

CAUTION

HOLD THE WEIGHT OF THE PHMU DURING THE REMOVAL. DO NOT LET THE PHMU DROP WHEN YOU REMOVE THE BOLTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE PHMU.

Data communicated from the PHMU is used to display the vibration parameters on the flight deck, display messages of any particle finding by the ODM, and to provide status and fault data for the PHMU and its associated sensors. Each channel of the EEC communicates with the PHMU independently. The engine vibration sensors, ODM, and P.25 sensor provide input directly to the PHMU.

During power up, the PHMU checks software compatibility with the EEC (using the Power On Built in Test). If a software compatibility issue between the PHMU and the EEC is identified, the EEC will set a fault message.



ANALYZER SYSTEM – PROGNOSTICS AND HEALTH MANAGEMENT UNIT (PHMU)

CHAPTER 7

LUBRICATION

ATA 79

SYMBOLS

Symbols used in this guide are explained below.

Special tooling is required.

LRU — The component is a Line Replaceable Unit (LRU).

PMT — A Post Maintenance Test is required.

WARNING — Avoid injury by following guidelines listed under this symbol.

CAUTION — Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of the Lubrication System.
2. Locate system components.
3. Describe the purpose of the auxiliary oil supply.
4. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Lubrication System supplies filtered, non-regulated pressurized oil to lubricate engine bearings, gears and accessory drives under all operating conditions. Oil is also used to clean engine parts, cool heated part surfaces, and warm engine fuel to prevent icing.

The system consists of five interactive subsystems, shown in the table.

The Lubrication and Scavenge Oil Pump (LSOP) ensures correct oil supply pressure and adequate scavenge capability. An Oil Control Module (OCM) helps to distribute oil. Heat exchangers listed below maintain oil temperatures within design limits.

- Air/Oil Heat Exchanger — AOHE
- Fuel/Oil Heat Exchanger — FOHE
- Integrated Drive Generator Oil/Oil Heat Exchanger — IDGOOHE

A Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV) controls oil flow to the FOHE and the AOHE.

An auxiliary oil supply that is part of a lubrication subsystem ensures that the Fan Drive Gear System (FDGS) journal bearings always have an available oil supply in the event of windmill or negative-G oil pressure conditions.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER’S SAFETY INSTRUCTIONS FOR EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

Last chance strainers in the oil supply tubes provide extra protection against blockage of oil jets in the bearing compartments and gearboxes. Oil system pressure, temperature, and quantity are monitored continuously.

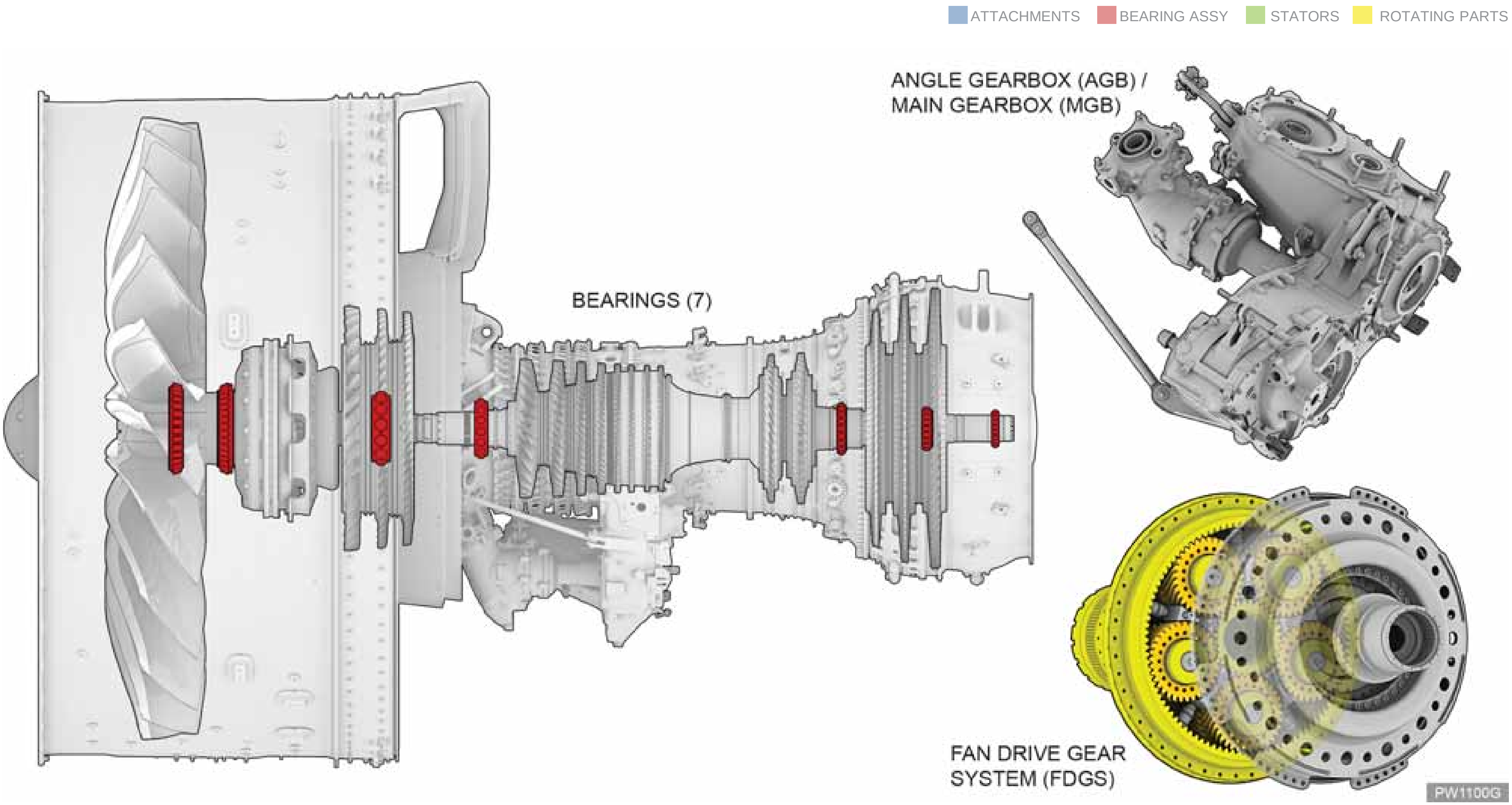
Breather air in the oil is removed by a deaerator in the oil tank and a deoiler in the Main Gearbox. The air is then vented overboard.

KEY FACT

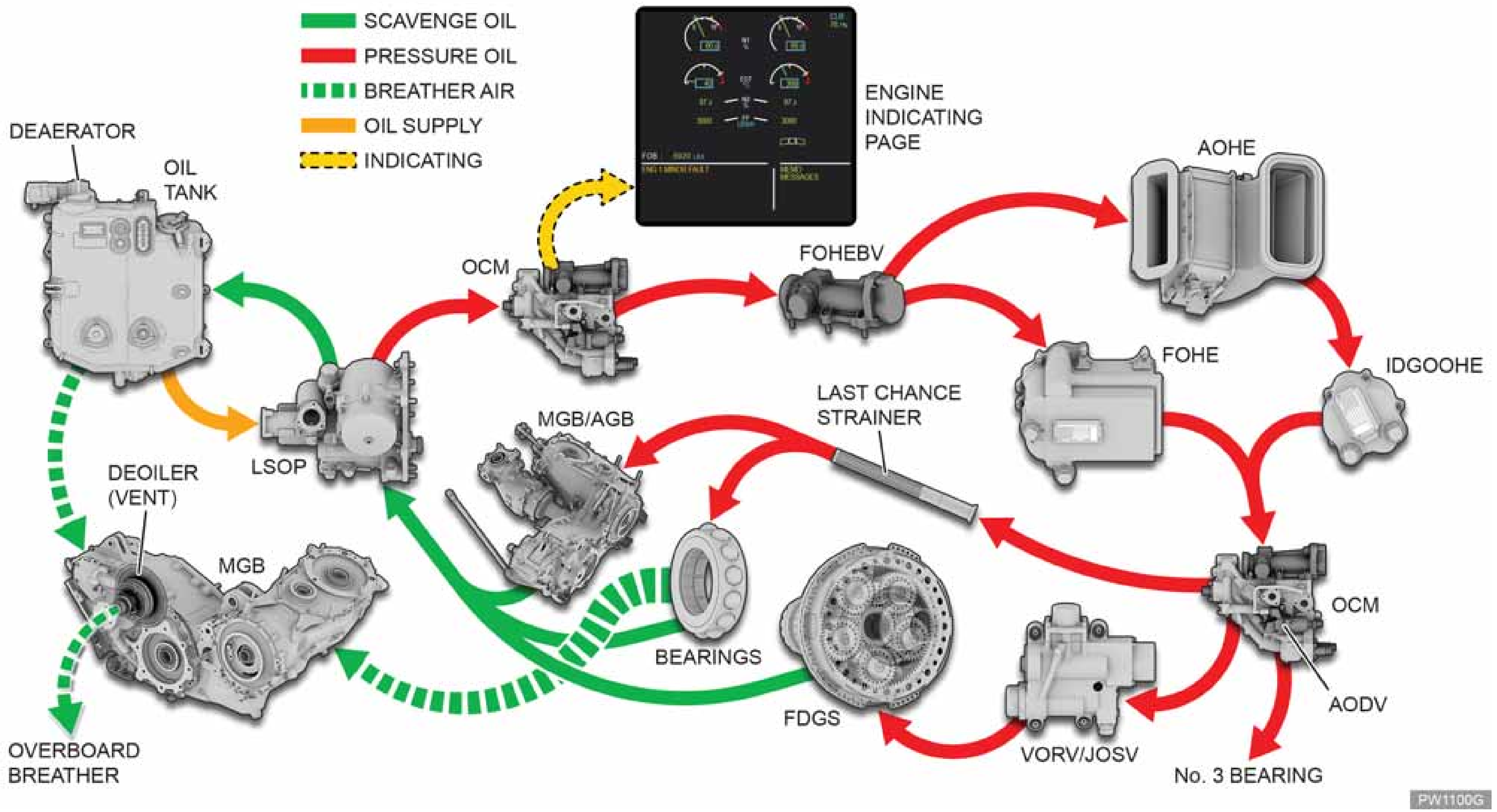
The engine’s oil system is referred to as a *hot tank* system due to the hot oil that is scavenged and returned to the tank for re-use. If the oil were allowed to cool before return to the tank, the resulting drop in pressure could invite pockets of air that would interrupt consistent oil flow to the engine bearings.

System	Function
Storage	• Stores, pressurizes, and deaerates engine oil supply in the oil tank
Distribution	• Supplies pressurized and filtered oil to lubricate, cool, and clean main bearings, gears, and accessory drives • Cleans and filters unwanted material before oil is used • Removes heat from the engine, using heat exchangers
Scavenge	• Removes oil from bearing compartments and returns it to the tank
Breather	• Removes air from the bearing compartments • Separates breather air from the oil and vents the air overboard
Indicating	• Provides information about oil quantity, temperature and pressure

LUBRICATION SUBSYSTEMS



PRIMARY OIL-DEPENDENT COMPONENTS



LUBRICATION SYSTEM CYCLE

Safety Conditions

CAUTION

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

STORAGE SYSTEM

The Storage System consists of a pressurized hot oil tank, which stores the oil and supplies a sufficient quantity to the engine's Lubrication Distribution System. Hot oil is returned to the tank through the Scavenge System.

Major oil tank features include:

- oil tank cap
- filler neck assembly
- deaerator
- oil quantity sight glass
- Oil Level Sensor (OLS)
- strainer
- scupper drain
- drain plug.

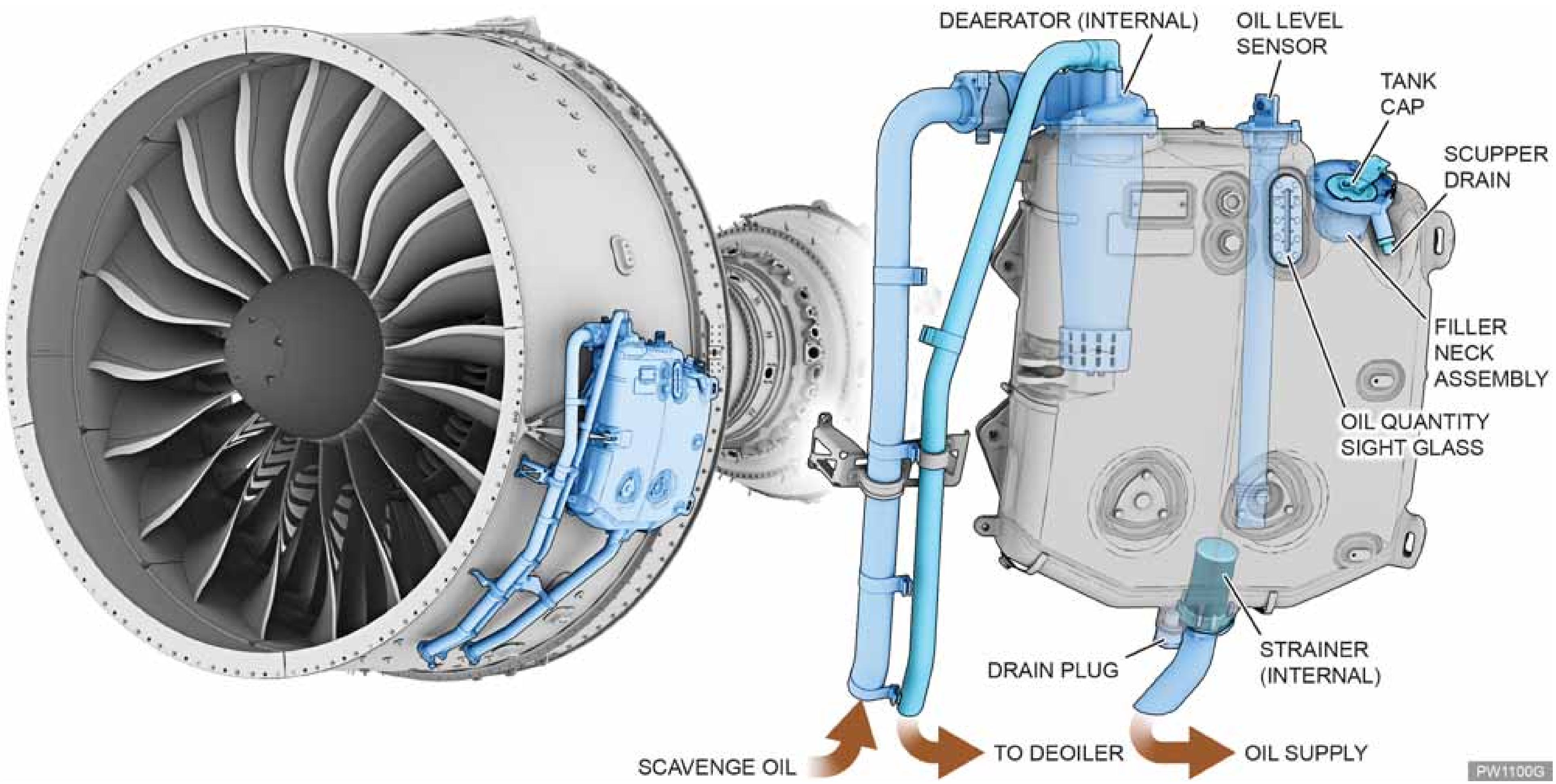
The oil tank assembly is located on the fan case at approximately 9:00. The tank supplies oil to the pressurization side of the Lubrication System.

The oil tank assembly is sized to provide 40 hours of operation without replenishing. The assembly is pressurized and has a total volume of 39.55 quarts, and a usable volume of 35 quarts.

The filler neck assembly provides a port for servicing the oil tank. A deaerator in the tank removes air bubbles as the oil goes into the tank. A pressure relief valve in the tank releases air and oil pressure to the deoiler in the Main Gearbox when necessary.

A hinged oil tank cap allows for oil servicing. A scupper drain vents spills overboard through the drain mast. The drain plug is used to empty the oil tank. A strainer at the bottom of the oil tank housing prevents impurities from entering the oil flow.

A sight glass shows the oil quantity in the tank and provides a visual indication of the amount of oil to be added. An Oil Level Sensor (OLS) positioned on top functions as part of the Lubrication Indicating System.



STORAGE SYSTEM – OIL TANK

STORAGE SYSTEM (Cont.)

Oil Tank Cap

Purpose:

LRU PMT

The oil tank is serviced through the oil tank cap.

Location:

The cap is located on the rear outboard corner on top of the tank.

Description:

The tank cap is secured in the installed position by a hinged, spring-loaded lock. A flapper valve in the manual gravity fill port prevents rapid oil loss in the event the tank cap is not correctly installed. The cap is sealed to the tank with a packing.

A metal strainer between the cap and flapper prevents large size debris from entering the tank during servicing.

Operation:

The cap can be removed for servicing by manually lifting the lever to release the lock.

Safety Conditions

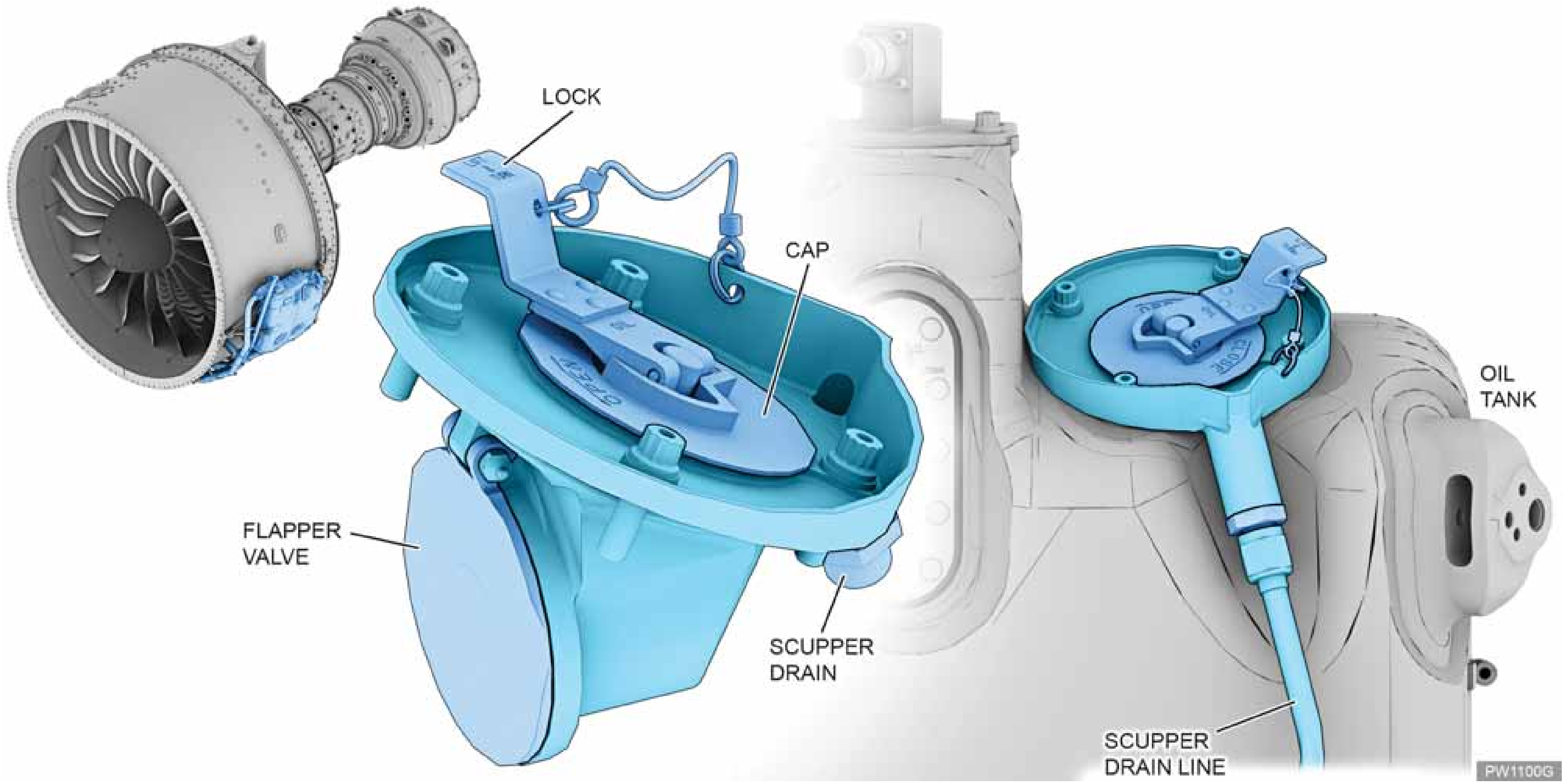
WARNING

DO NOT OPEN THE OIL TANK CAP UNTIL FIVE MINUTES MINIMUM AFTER ENGINE SHUTDOWN. THIS WILL LET THE PRESSURE BLEED OFF. IF YOU DO NOT OBEY THIS WARNING, HOT OIL CAN BURN YOUR EYES AND SKIN.

CAUTION

YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

MAKE SURE THAT YOU CLOSE THE OIL TANK CAP COMPLETELY AND THAT THE OIL TANK CAP LEVER IS DOWN AND LOCKED. IF YOU DO NOT OIL CAN COME OUT OF TH ETANK AND AN IN-FLIGHT SHUTDOWN MAY OCCUR.



STORAGE SYSTEM – OIL TANK CAP

STORAGE SYSTEM (Cont.)

Filler Neck Assembly

Purpose:

The filler neck assembly provides a securable and sealable port for servicing the oil tank assembly.

Location:

The assembly is attached to the oil tank housing.

Description:

Four bolts attach the assembly to the oil tank housing. An O-ring around the assembly provides oil sealing between it and the tank housing.

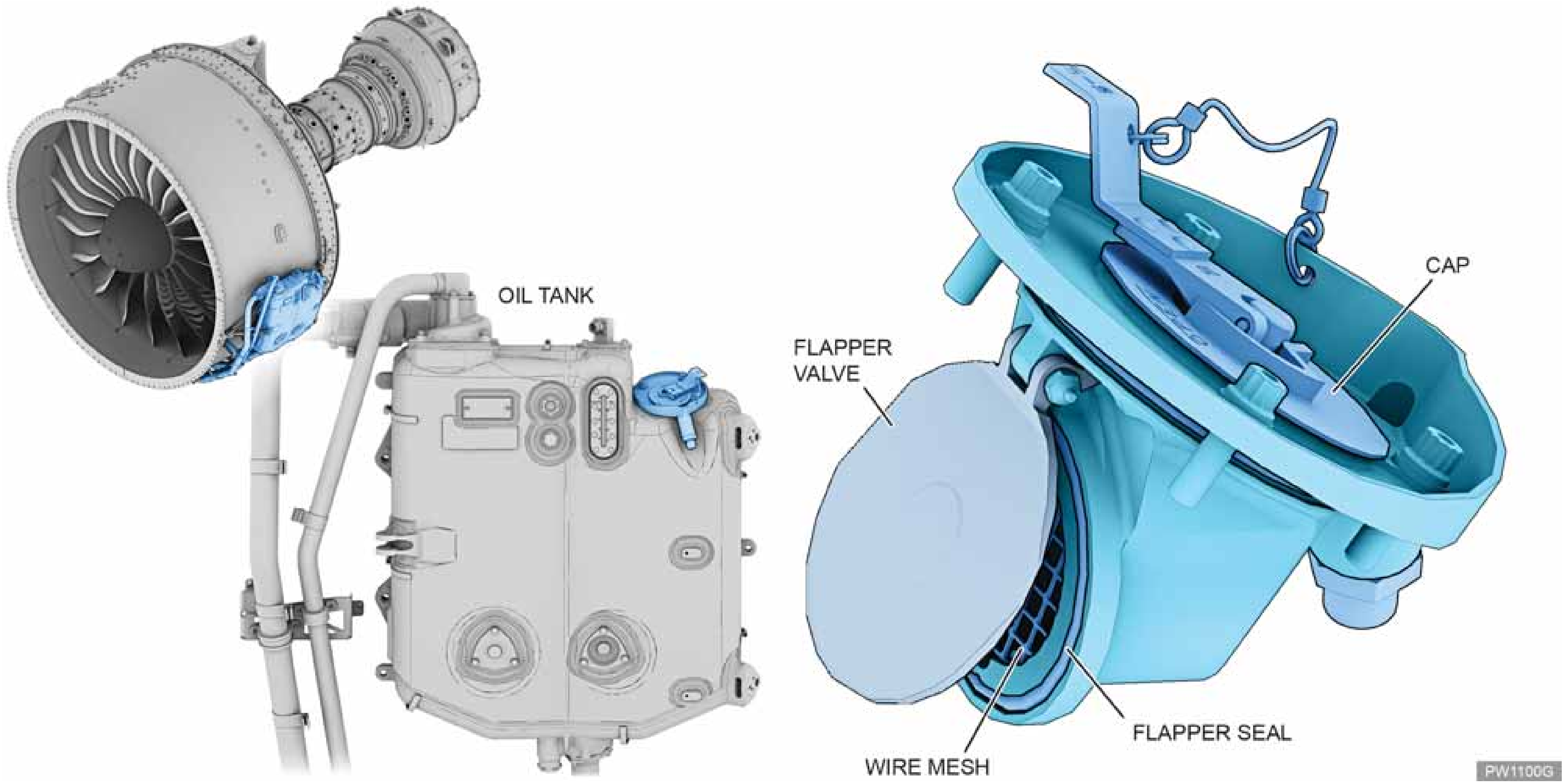
The filler neck assembly has a wire mesh and flapper valve at its base. The wire mesh screen provides protection from large debris entering the oil tank assembly. The flapper valve is mounted on a hinge that allows the valve to open from the weight of the oil during oil servicing, and close from the weight of the flapper valve after servicing is complete.

Operation:

During engine operation, the internal pressure developed inside the oil tank assembly keeps the flapper valve in the closed position, preventing rapid loss of oil in the event the cap is not properly installed.

The cap is secured in the installed position by a spring-loaded lock. To prevent loss, a cable attaches the cap to the filler neck assembly.

Oil spillage is retained by a rim around the filler neck assembly and empties out the drainage port that is attached to an oil drain tube. The rim is an integral part of the filler neck assembly.



STORAGE SYSTEM – FILLER NECK ASSEMBLY

STORAGE SYSTEM (Cont.)

Deaerator

Purpose: LRU PMT

The deaerator removes air from the scavenge oil returned to the oil tank assembly, and maintains its pressurization.

Location:

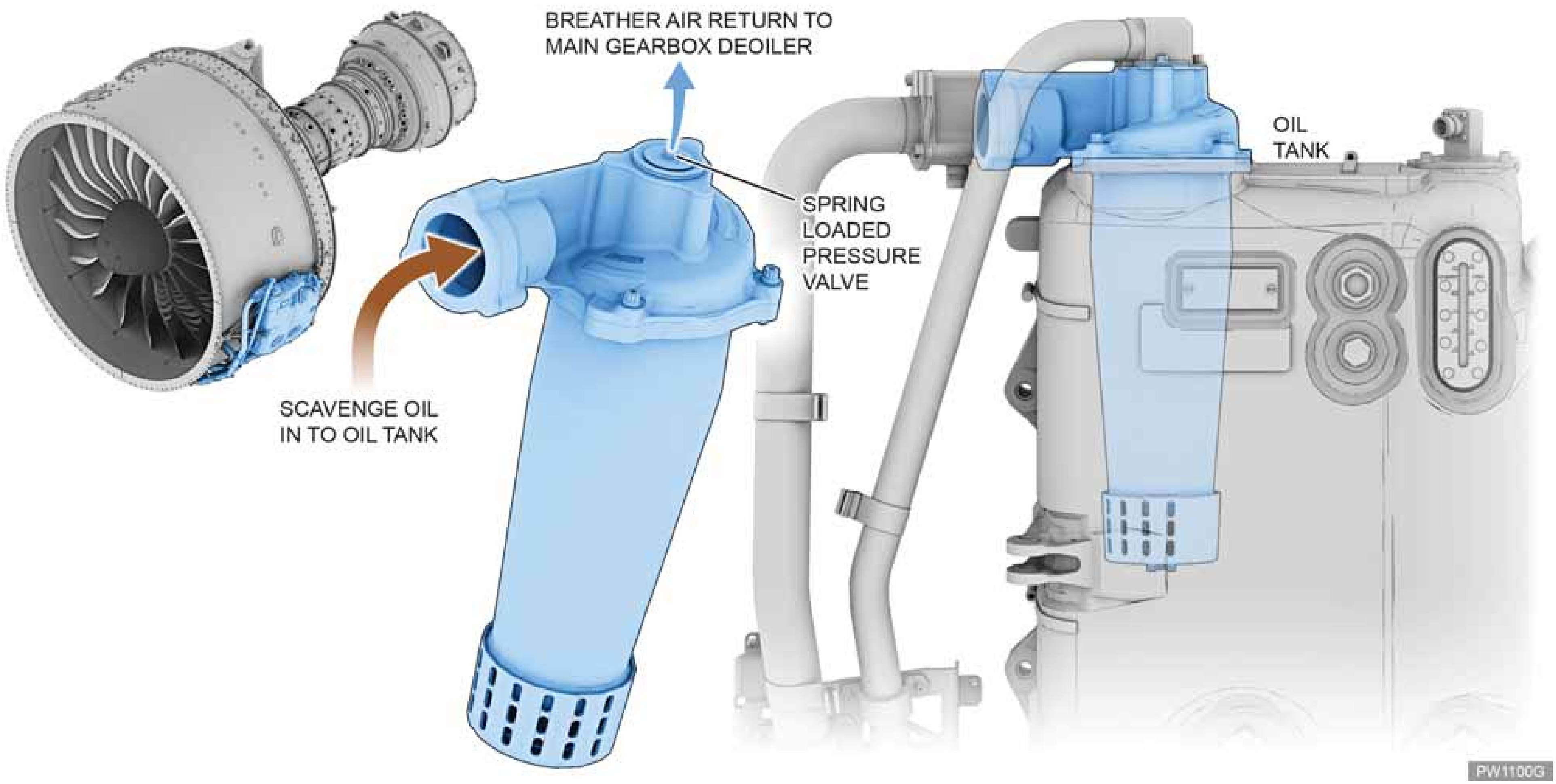
The deaerator is installed inside the oil tank housing.

Description:

Four bolts attach the deaerator to the oil tank housing. A pressurization valve installed in the top of the deaerator is spring-activated and maintains pressure in the oil tank assembly.

Operation:

Air-saturated oil enters the deaerator and follows a circular passageway where the oil is separated from the air. The air removed from the scavenge oil is vented to the engine's Main Gearbox Assembly through the main oil tank deaerator vent tube.



STORAGE SYSTEM – DEAERATOR

Safety Conditions

WARNING

YOU MUST OBEY ALL THE LOCAL STANDARD SAFETY PRECAUTIONS.

CAUTION

DO NOT DRY MOTOR OR OPERATE THE ENGINE WITHOUT SUFFICIENT OIL. THIS CAN CAUSE DAMAGE TO THE ENGINE.

STORAGE SYSTEM (Cont.)

Oil Quantity Sight Glass

Purpose: LRU PMT

The oil quantity sight glass provides a visual indication of the oil level in the oil tank.

Location:

The sight glass is located directly to the left of the fill port.

Description:

Ten screws attach the sight glass to the oil tank assembly. The tank is marked in both U.S. quarts and in liter gradations.

Operation:

Oil that is distributed in the oil system during engine operation and returned to the oil tank at shutdown is referred to as *oil gulp*. Oil gulp for the PW1100G-JM can be as much as 10.1 quarts (9.6 liters), leaving 4.8 quarts (4.5 liters) of usable oil in the tank.

In extremely cold environments (-34° F/-37° C or below) an additional 3.5 quart (3.3 liter) gulp in static oil level may exist during motoring or low power operation

STORAGE SYSTEM – OIL QUANTITY SIGHT GLASS

STORAGE SYSTEM (Cont.)

Oil Tank Strainer

Purpose:

LRU

The oil tank strainer prevents introduction of large debris into the Lubrication System.

Location:

The strainer is installed at the oil pump supply port at the bottom of the oil tank housing.

Description:

The stainless steel strainer has a mesh to filter debris. The strainer is mounted to the oil tank housing with three bolts. An O-ring installed at the bottom of the strainer prevents leakage.

STORAGE SYSTEM – OIL TANK STRAINER

Safety Conditions

WARNING

WHENEVER POSSIBLE, KEEP FUEL AND OIL AWAY FROM YOUR SKIN. USE PROTECTIVE CLOTHES. FUEL AND OIL CAN DRY YOUR SKIN AND CAUSE SKIN IRRITATION.

CAUTION

DO NOT PRY OR PUSH ON THE RETENTION TAB WHEN YOU REMOVE OR INSTALL THE DRAIN PLUG. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE DRAIN PLUG

STORAGE SYSTEM (Cont.)

Oil Tank Drain Plug

Purpose: LRU PMT

The drain plug is removed to empty the oil tank.

Location:

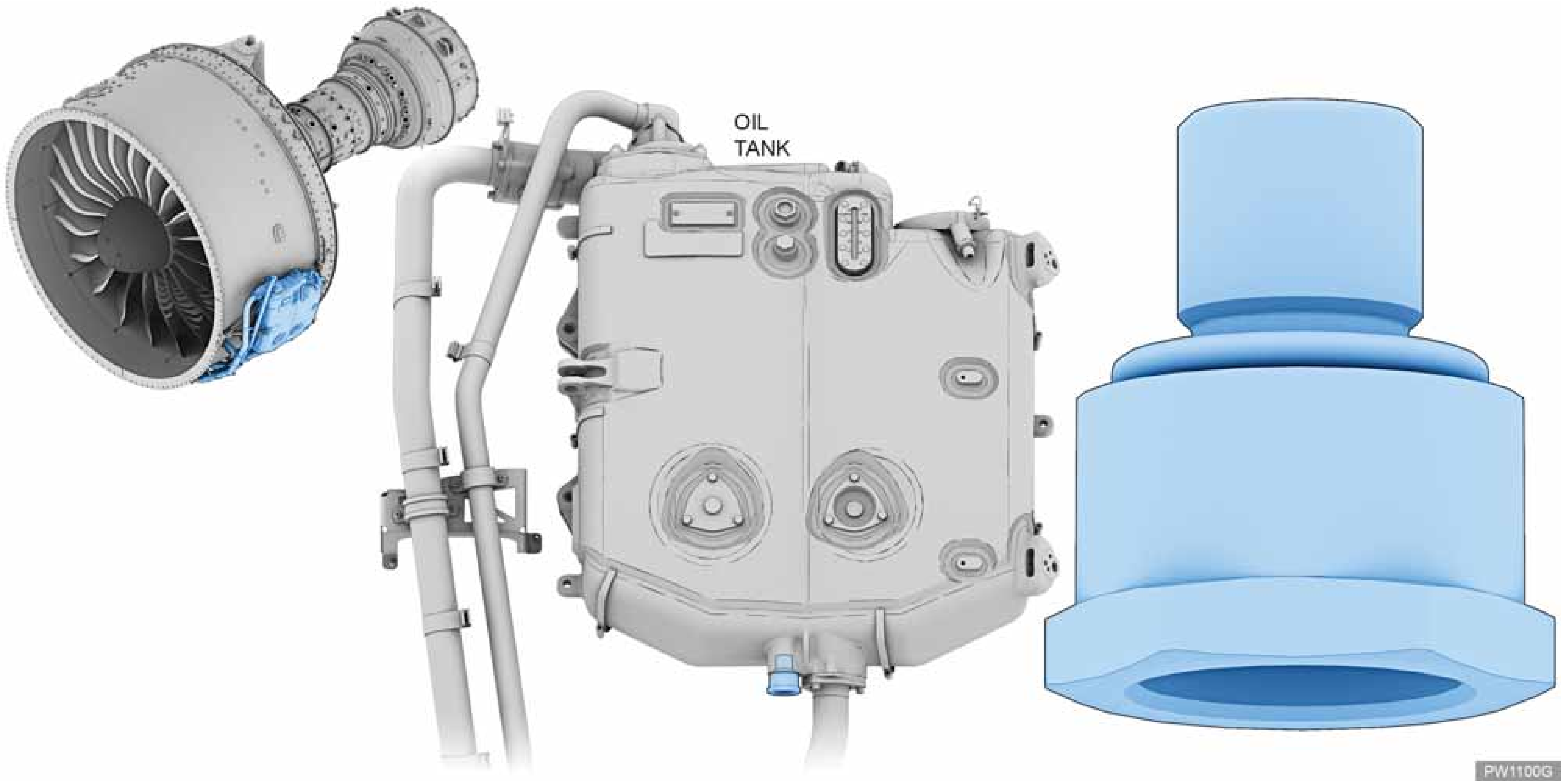
The drain plug is located at the bottom of the oil tank.

Description:

The drain plug is threaded into the drain plug port, which is integral to the oil tank housing. An O-ring around the drain plug prevents oil leakage.

Operation:

When the drain plug is removed, the O-ring is inspected and replaced if damaged.



STORAGE SYSTEM – OIL TANK DRAIN PLUG

DISTRIBUTION SYSTEM

The Distribution System supplies non-regulated pressure oil to lubricate, cool, and clean engine bearings, gears, and accessory drives. The system has both primary distribution and auxiliary oil lubrication operations. The auxiliary capability provides a secondary source of oil for the journal bearings in case of negative gravity (negative-G) or windmill conditions.

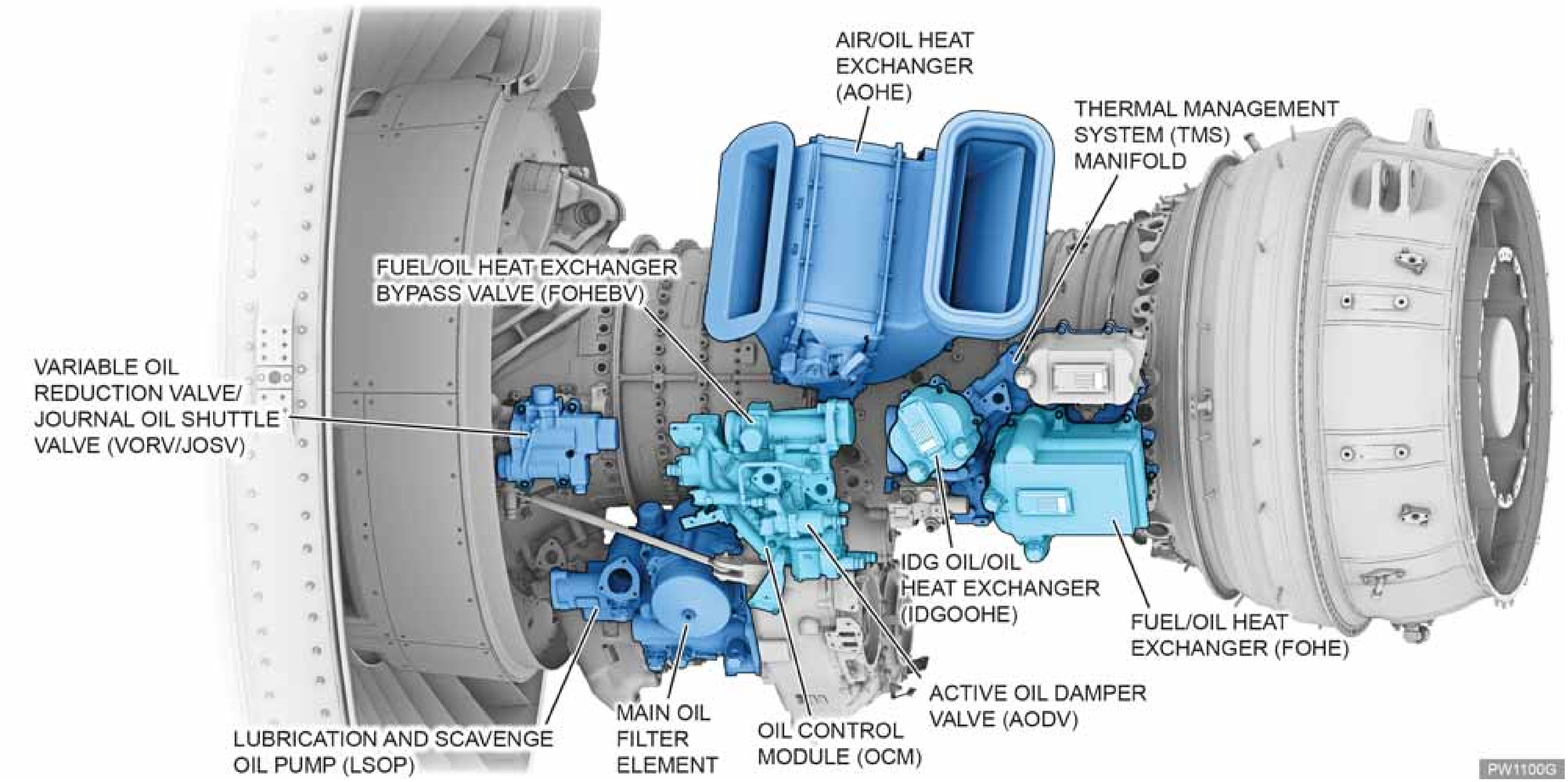
Components are listed below.

Primary Distribution

• Lubrication and Scavenge Oil Pump	LSOP
• Main oil filter element	
• Oil Control Module	OCM
• Thermal Management System	TMS
• Fuel/Oil Heat Exchanger Bypass Valve	FOHEBV
• Fuel/Oil Heat Exchanger	FOHE
• Air/Oil Heat Exchanger	AOHE
• IDG Oil/Oil Heat Exchanger	IDGOOHE
• Active Oil Damper Valve	AODV
• Variable Oil Reduction Valve	VORV
• Journal Oil Shuttle Valve	JOSV
• Last chance oil strainers	

Auxiliary Lubrication

- Fan drive gear train
- Windmill/auxiliary pump
- Sprag clutch gear assembly
- Auxiliary oil reservoir



DISTRIBUTION SYSTEM

DISTRIBUTION SYSTEM (Cont.)

Lubrication and Scavenge Oil Pump (LSOP)

Purpose:

LRU PMT

The Lubrication and Scavenge Oil Pump pressurizes oil and sends it from the oil tank to the engine bearings, seals, gears and accessory drives. Its chip collectors are part of the Scavenge System, and the pump itself returns scavenge oil to the oil tank.

Location:

The pump is installed on the left front side of the Main Gearbox.

Description:

The pump has seven positive displacement, gear-type pump stages. One stage supplies pressure oil, and the other six stages scavenge oil. The six scavenge pump stages receive oil through a combination of external tubes and MGB core passages. Each stage is turned by the MGB at a speed proportional to N2.

The pump's splined drive shaft is inserted to a splined drive in the gearbox and attached with captive bolts. A face seal is used between the pump and the gearbox. A guide pin on the pump housing helps with installation of the pump and seal.

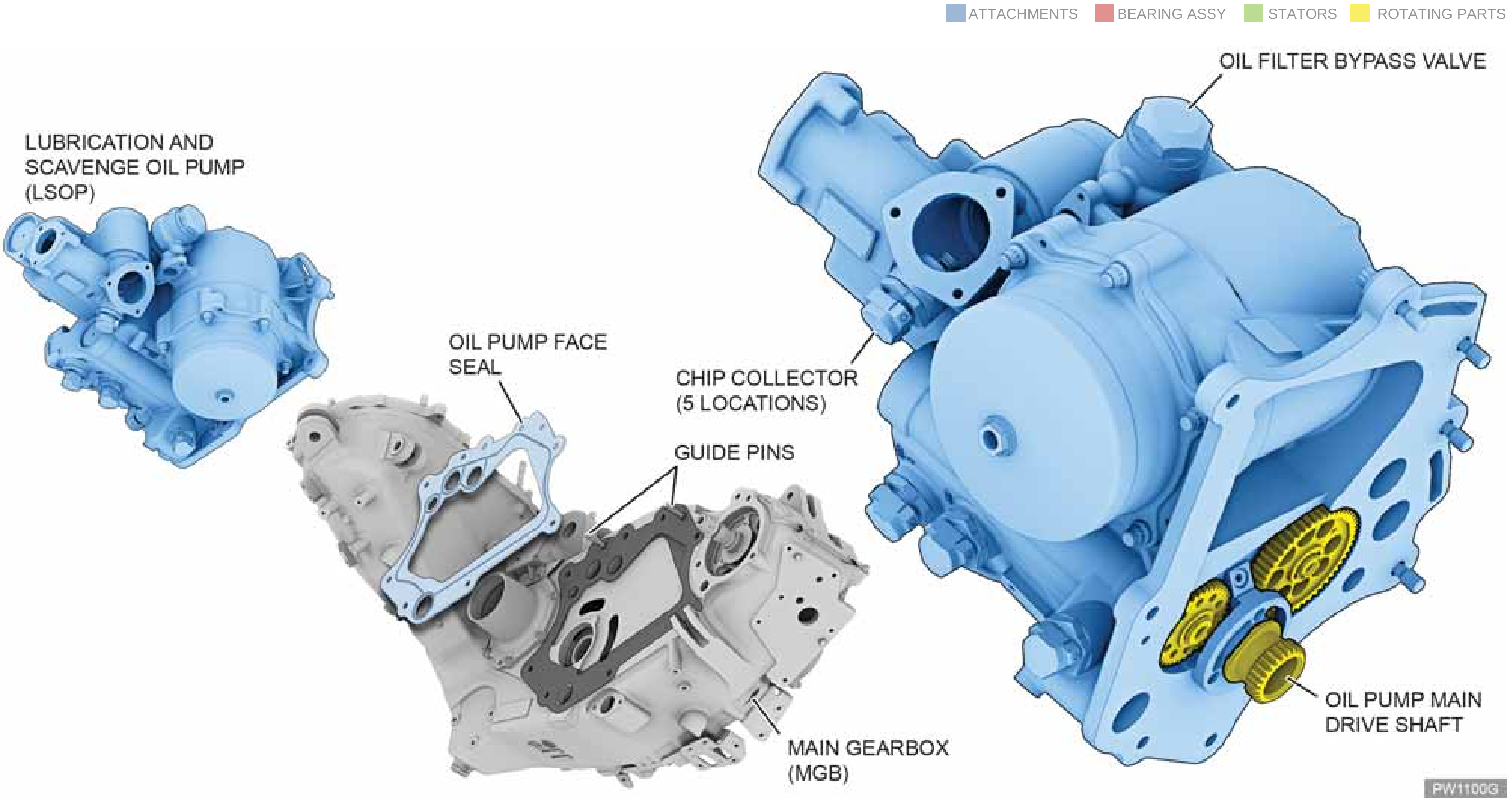
The pump has a pressure relief valve to limit the maximum main oil pressure to protect system components downstream of the pump.

Safety Conditions

CAUTION

HOLD THE WEIGHT OF THE OIL PUMP DURING THE INSTALLATION. DO NOT LET THE OIL PUMP HANG ON THE DOWEL PINS OR DRIVE SHAFT WITHOUT THE BOLTS ENGAGED. IF YOU DO, THE OIL PUMP COULD DISENGAGE FROM THE GEARBOX AND DROP. THE OIL PUMP WEIGHT IS APPROXIMATELY 66 LBS (30 KGS). IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE OIL PUMP.

BE CAREFUL WHEN REMOVING THE OIL PUMP. MAKE SURE THERE IS NO INTERFERENCE WITH THE OIL PUMP DRIVESHAFT WITH ANY OF THE OTHER PARTS. IF YOU DO NOT OBEY THIS CAUTION, DAMAGE TO THE OIL PUMP AND ENGINE CAN OCCUR.



DISTRIBUTION SYSTEM – LUBRICATION AND SCAVENGE OIL PUMP (LSOP)

DISTRIBUTION SYSTEM

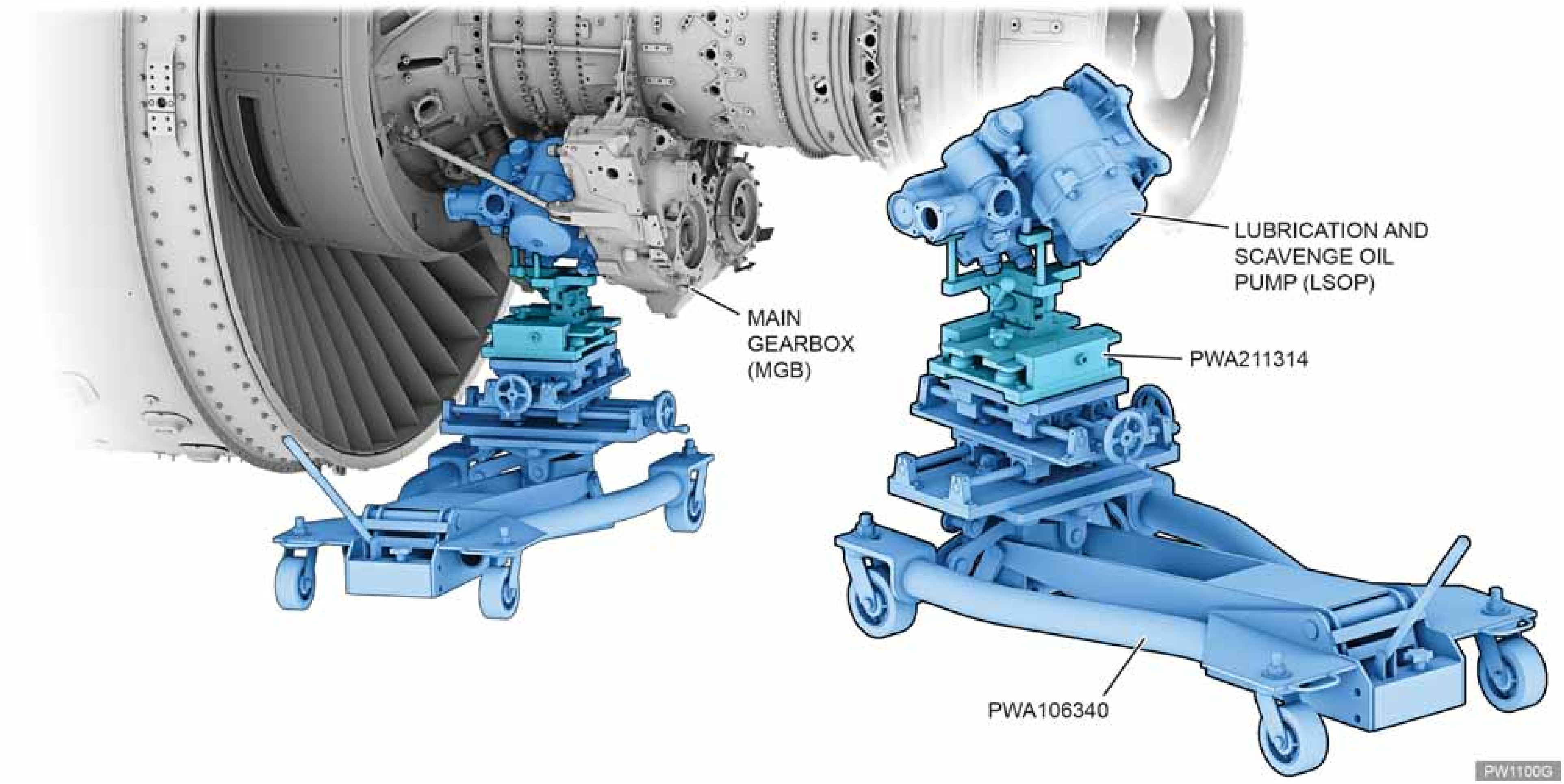
Lubrication and Scavenge Oil Pump (LSOP) (Cont.)

Operation:

1. A single pressure pump stage delivers oil supply to oil-dependent components at pressures that vary with the engine's N2 speeds.

2. The six scavenge pumps return oil from all bearing compartments, the FDGS compartment, the Angle Gearbox, and the Main Gearbox.

Special tool PWA211314 is required to remove and install the LSOP.



DISTRIBUTION SYSTEM – LUBRICATION AND SCAVENGE OIL PUMP REMOVAL/INSTALLATION TOOL

DISTRIBUTION SYSTEM (Cont.)

Main Oil Filter Element

Purpose:

LRU PMT

The main oil filter element removes solid contaminants from the pressurized oil sent from the Lubrication and Scavenge Oil Pump.

Location:

The main oil filter element is located on the LSOP.

Description:

The component has a disposable, non-cleanable dual-element design that uses a filter within a filter. Oil flows through the filter from the outer diameter (O.D.) to the inner diameter (I.D.).

The primary element has a 30-micron rating for fine filtration. The secondary element has a 150-micron rating for coarse filtration.

Operation:

The oil filter housing has an anti-drainback feature for servicing. An oil filter differential pressure sensor triggers a filter clog message to display on the flight deck.

Primary oil filter bypass may occur during cold starting. If the primary filter becomes clogged, the bypass valve will open, allowing oil to flow through the secondary element.

Safety Conditions

WARNING

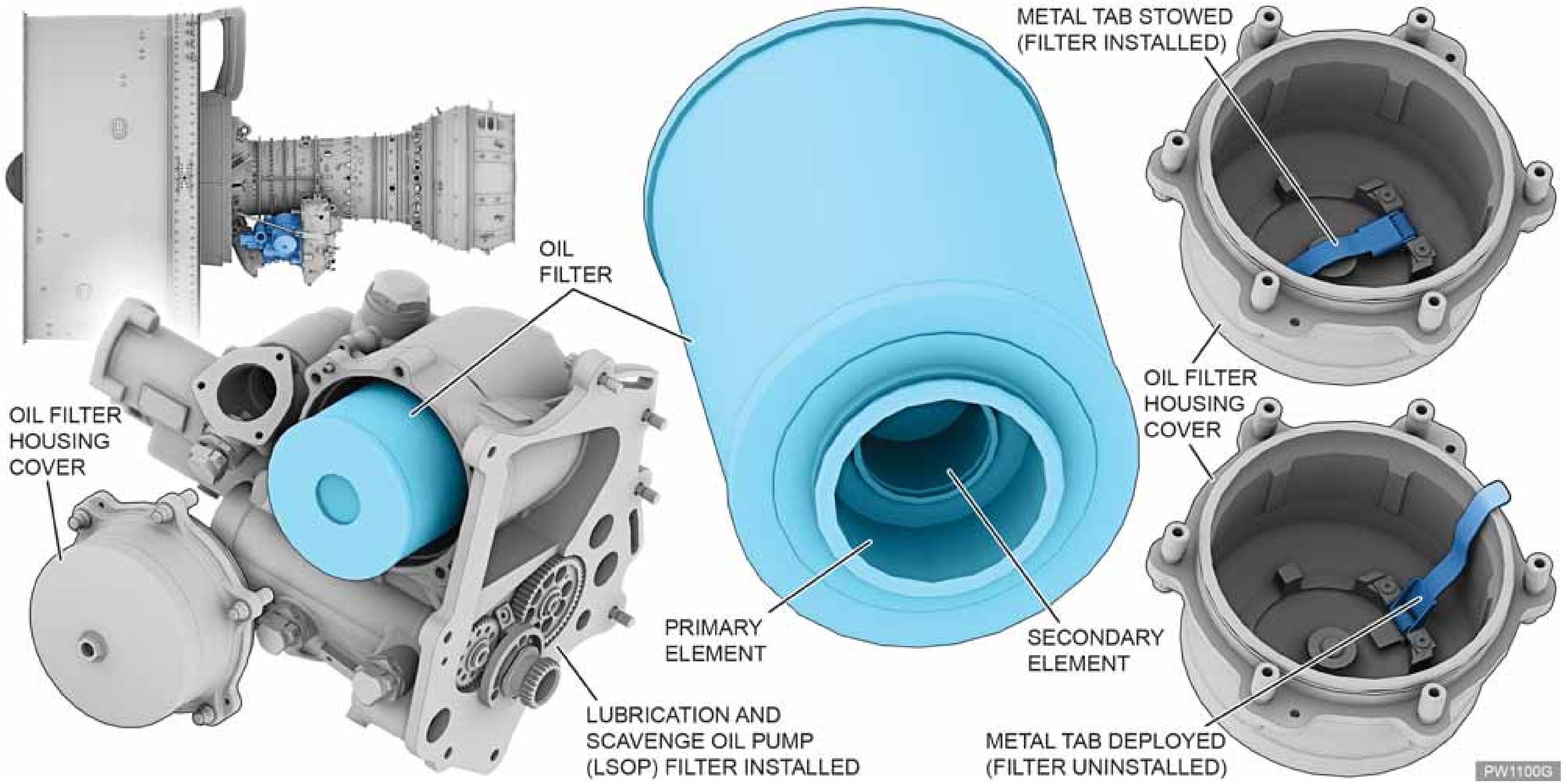
WAIT 5 MINUTES TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE DOING THIS PROCEDURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

A clogged primary filter is indicated to the flight deck through a differential pressure sensor. Because there is a secondary element, an in-flight shutdown is not necessary.

A small spring-loaded metal tab is attached to the bottom of the inner diameter of the cover as a mistake-proofing feature for changing the filter element. When the oil filter cover is removed and the oil filter element is not present in the cover, the metal tab will protrude from the cover. This helps to prevent installation of the cover to the oil pump housing if an oil filter is not installed.

When properly installing an oil filter into the housing, the metal tab is held down inside the cover by the oil filter element. This allows the maintenance technician to correctly install the oil filter cover to the housing.

An inlet shutoff valve prevents engine operation without a filter installed. If the engine is started and the filter is not installed, the bypass valve will open once the oil pressure rises to a certain value. The FADEC will then trigger an ENG 1(2) OIL FITLER IN BYPASS warning, which is NO GO per the MEL.



DISTRIBUTION SYSTEM – MAIN OIL FILTER ELEMENT

DISTRIBUTION SYSTEM

Main Oil Filter Element (Cont.)

Oil Filter Clogging Messages

An indication that the main oil filter is nearing the end of its service life is signaled by the amber warning message ENG 1(2) OIL FILTER DEGRAD ECAM. No flight crew action is required. The filter clog message should be reported as an engine discrepancy. The flight may proceed, but a log book entry must be made and the filter must be changed per Minimum Equipment List (MEL) direction.

An indication that the main oil filter is clogging and bypass is occurring is signaled by the amber warning message ENG 1(2) OIL FILTER CLOG ECAM. No flight crew action is required. The filter clog message should be reported as an engine discrepancy. As oil bypasses the main oil filter, the secondary oil filter will continue to filter the oil. If the secondary oil filter also clogs, the engine oil pressure will decrease.

If oil pressure decreases below the red limit, and is confirmed by both the ECAM red warning message OIL LO PR and the Master Warning light, the engine should be shut down, flight conditions permitting.

An early indication that the filter is becoming clogged may occur if the OIL FILTER CLOG ECAM message displays (even if only for a few seconds) with oil temperature above 41°C, during or shortly after engine start. If the warning disappears as oil temperature rises, the flight may proceed, but a log book entry must be made and the filter must be changed per MEL direction. If the warning remains on, the filter must be changed prior to flight.

DISTRIBUTION SYSTEM (Cont.)

Oil Control Module (OCM)

Purpose: LRU PMT

The Oil Control Module receives pressurized, filtered oil from the Lubrication and Scavenge Oil Pump and distributes the oil to the various engine compartments and heat exchangers through internal cored passages and tubes.

Location:

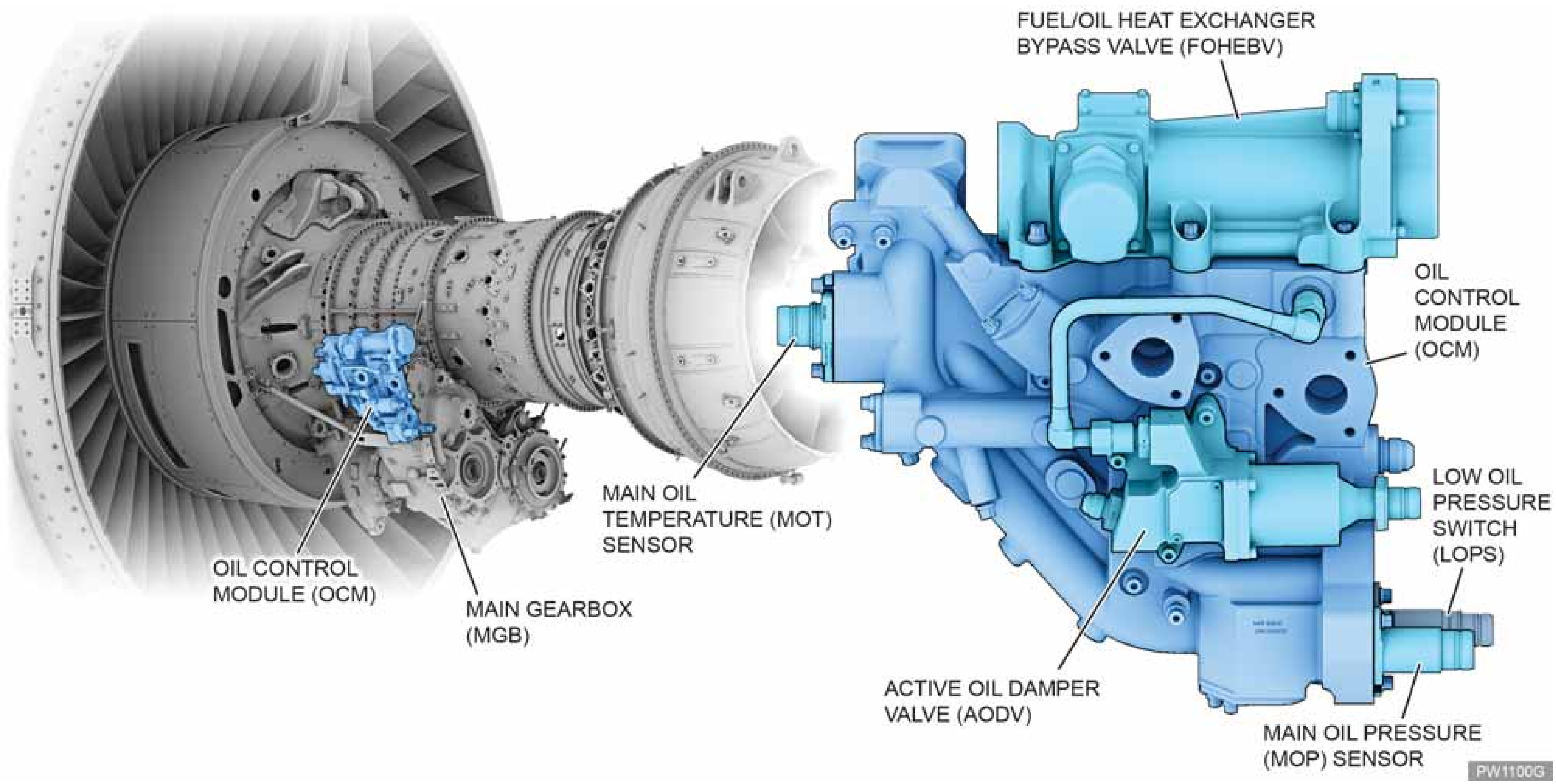
The OCM is located on the left side of the Main Gearbox.

Description:

The OCM greatly reduces the number of external oil lines required to deliver pressurized oil. It services oil components in both the Distribution and Indicating subsystems.

The OCM provides the Distribution System with accurate control of fuel flow. LRUs are centered around the body of the OCM to simplify maintenance.

Oil Components Mounted to OCM		
Distribution System	• Active Oil Damper Valve	AODV
	• Fuel/Oil Heat Exchanger Bypass Valve	FOHEBV
Indicating System	• Low Oil Pressure Switch	LOPS
	• Main Oil Pressure sensor	MOP
	• Main Oil Temperature sensor	MOT



DISTRIBUTION SYSTEM – OIL CONTROL MODULE (OCM) COMPONENTS

DISTRIBUTION SYSTEM

Oil Control Module (OCM) (Cont.)

Operation:

Oil flows from the LSOP through the oil filter and then through internal passages of the Main Gearbox casting to the OCM, where it is divided into four oil flow paths:

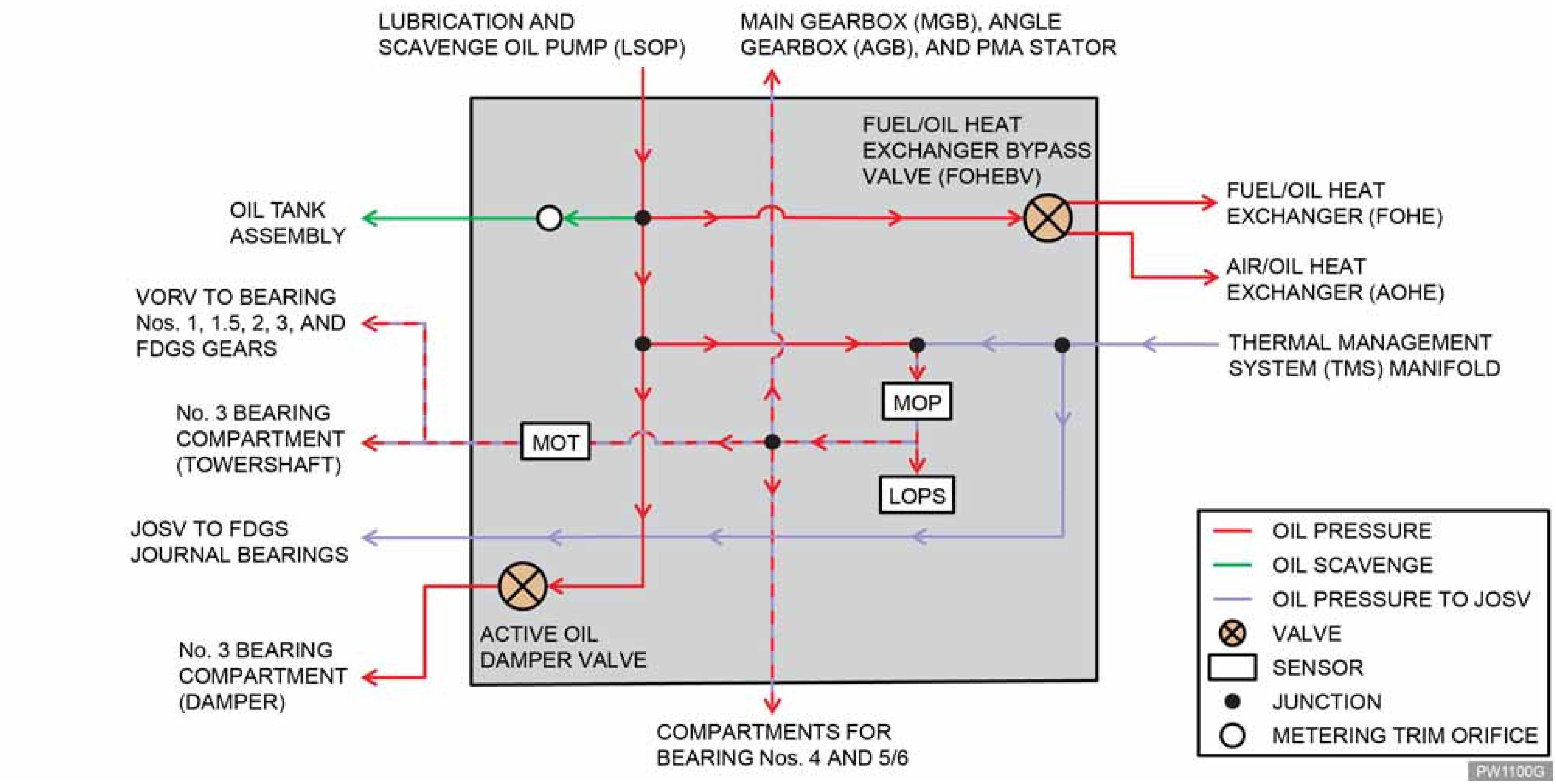
1. To the metering trim orifice, which sets minimum oil pressure and then flows back to the oil tank.

2. To the FOHEBV, which sends the oil to the AOHE and FOHE to be cooled. This oil then returns to the OCM and takes two separate paths:

   i. Through the OCM and the out to the JOSV to send the coolest oil directly to the journal bearings in the FDGS.

   ii. To mix with oil coming from the LSOP. The mixture then passes the MOP sensor, LOPS, and MOT sensor and goes out to the VORV. The VORV controls the oil flow to the forward bearing compartment and the No. 3 Bearing, tower shaft, bearing nos. 4, 5, and 6, and the main and angle gearboxes.

3. To the AODV, where hot oil from the LSOP goes directly to the CIC to dampen vibration of the No. 3 Bearing outer race.



DISTRIBUTION SYSTEM – OIL CONTROL MODULE (OCM) OPERATION

DISTRIBUTION SYSTEM (Cont.)

Thermal Management System (TMS) Manifold

Purpose:

LRU PMT

The Thermal Management System manifold uses heat exchangers to control the temperatures of engine oil, Integrated Drive Generator (IDG) oil and fuel, within limits.

Location:

The TMS manifold is located at 9:00.

Description:

Heat generated by bearings, seals, pumps and other mechanical components is dissipated through heat exchangers to engine fuel flow or to fan duct air. The system is comprised of three fluid circuits: a separate IDG oil circuit, an engine oil circuit, and an engine fuel circuit.

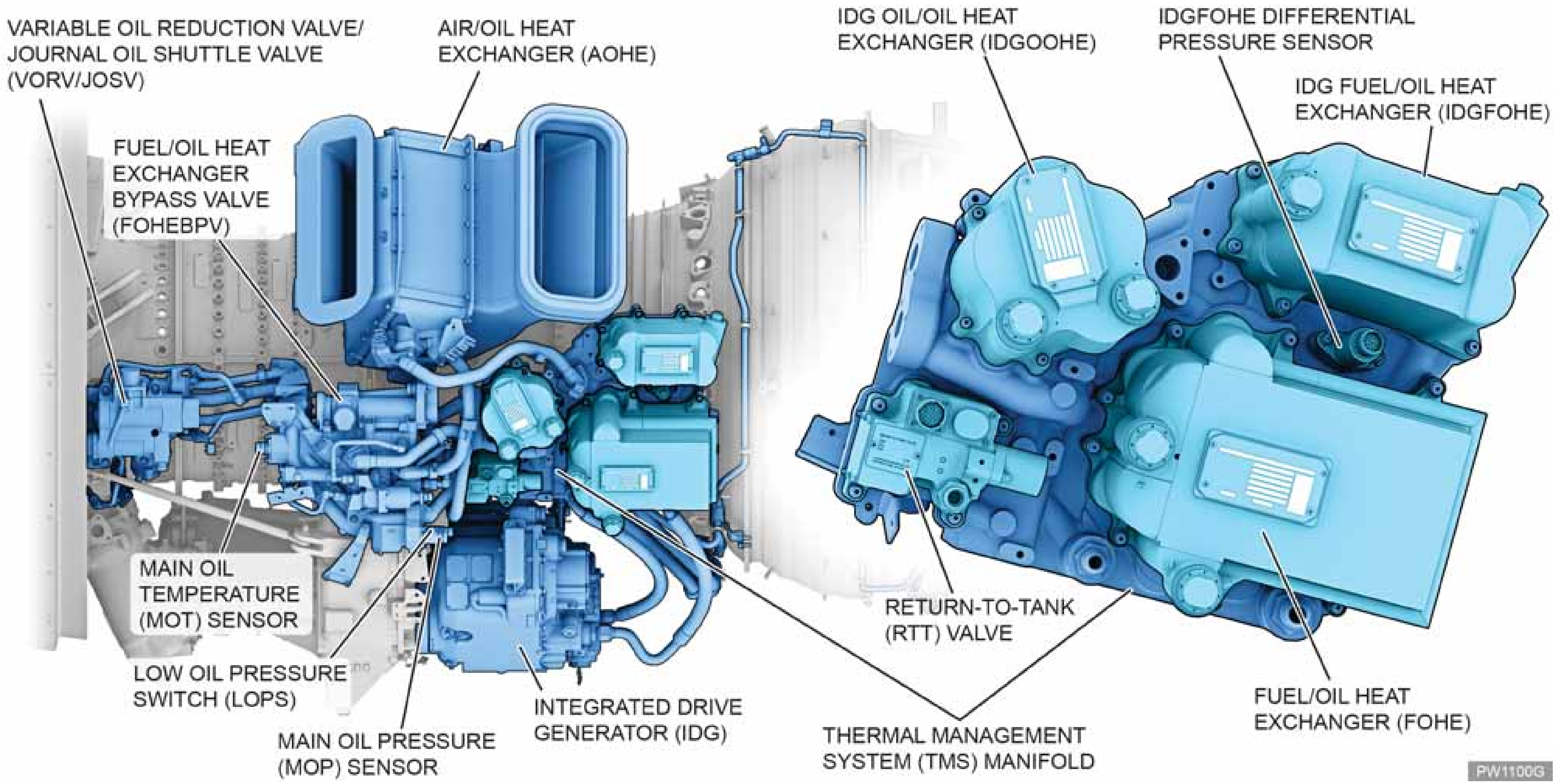
The engine fuel flow is the primary heat sink for the generator and engine oil circuits. Heat is added to the fuel flow from fuel pumps, the Integrated Drive Generator fuel/oil heat exchanger (IDGFOHE), and the engine fuel-oil heat exchanger (FOHE). Additional flow through the IDGFOHE, which will draw more heat from the generator oil system, can be achieved by returning heated fuel back into the aircraft fuel tank system using the Return to Tank Valve (RTTV).

The secondary heat sink is the bypass air. Heat from the engine oil system is transferred through the engine Air/Oil Heat Exchanger (AOHE).

Additional heat transfer between the engine oil system and the IDG oil system occurs at the IDG oil/oil heat exchanger (IDGOOHE).

Operation:

The FADEC actively controls the Fuel Oil Heat Exchanger Bypass Valve (FOHEBV) to maintain fuel and engine oil within thermal limits at all operating conditions. The FADEC monitors operation via the Main Oil Temperature (MOT) sensor located at the supply to the FDGS and bearings, and the fuel temperature sensor (Tf) located within the IFPC, upstream of the fuel metering valve.



DISTRIBUTION SYSTEM – TMS MANIFOLD AND HEAT EXCHANGE COMPONENTS

DISTRIBUTION SYSTEM (Cont.)

Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV)

Purpose: LRU PMT

The FOHEBV controls and distributes oil flow between the Fuel/Oil Heat Exchanger and the Air/Oil Heat Exchanger.

Location:

The FOHEBV is attached to the Oil Control Module.

Description:

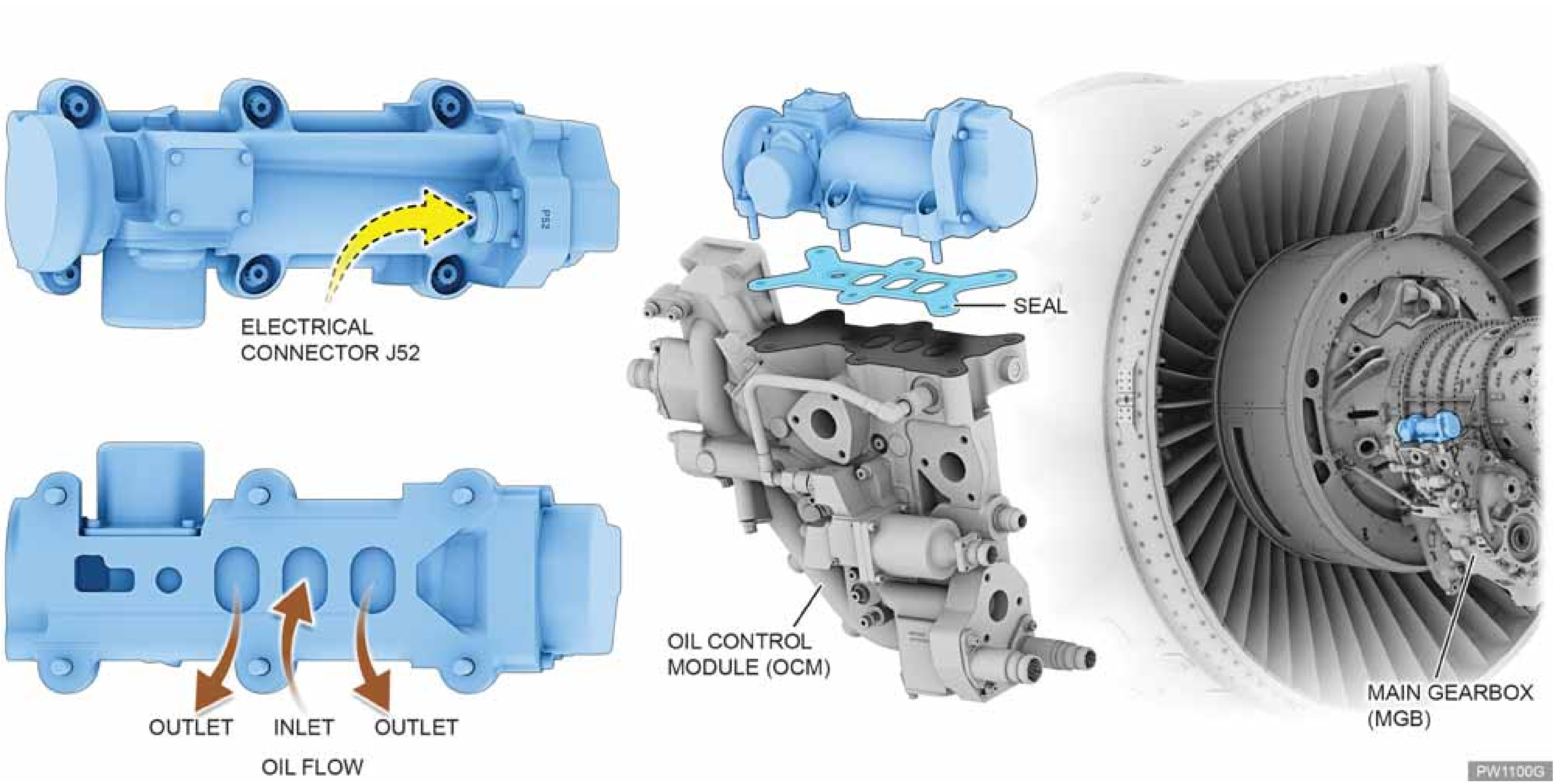
The dual-channel FOHEBV is controlled by the EEC. Valve position feedback is also provided to the EEC via Linear Variable Differential Transformer (LVDT) on one channel.

Six bolts attach the FOHEBV to the OCM. A seal plate is installed between the valve and the OCM to prevent oil leakage.

Oil enters the FOHEBV inlet port through a cored passage in the OCM. Oil exits the FOHEBV through two separate outlet ports to cored passages in the OCM. One outlet port sends oil to the Fuel/Oil Heat Exchanger (FOHE). The other outlet port sends oil to the Air/Oil Heat Exchanger (AOHE).

Valve position is based primarily on fuel temperature.

Oil flow increases to the FOHE if fuel temperature is low. The failsafe position is maximum flow to the FOHE, or 92.5 percent of total oil flow.



DISTRIBUTION SYSTEM – FUEL/OIL HEAT EXCHANGER BYPASS VALVE (FOHEBV)

DISTRIBUTION SYSTEM

Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV) (Cont.)

Operation:

1. The FOHEBV increases oil flow to the AOHE if the fuel temperature is greater than a specified value.

2. The increased oil flow to the AOHE decreases the oil flow through the FOHE, reducing the amount of heat transfer to the fuel in the FOHE.

3. The bypass valve distributes a minimum of 7.5 percent of the engine oil to the AOHE during engine operation.

DISTRIBUTION SYSTEM (Cont.)

Fuel/Oil Heat Exchanger (FOHE)

Purpose: LRU PMT

The Fuel/Oil Heat Exchanger transfers heat from engine oil to prevent or eliminate ice formation in the fuel.

Location:

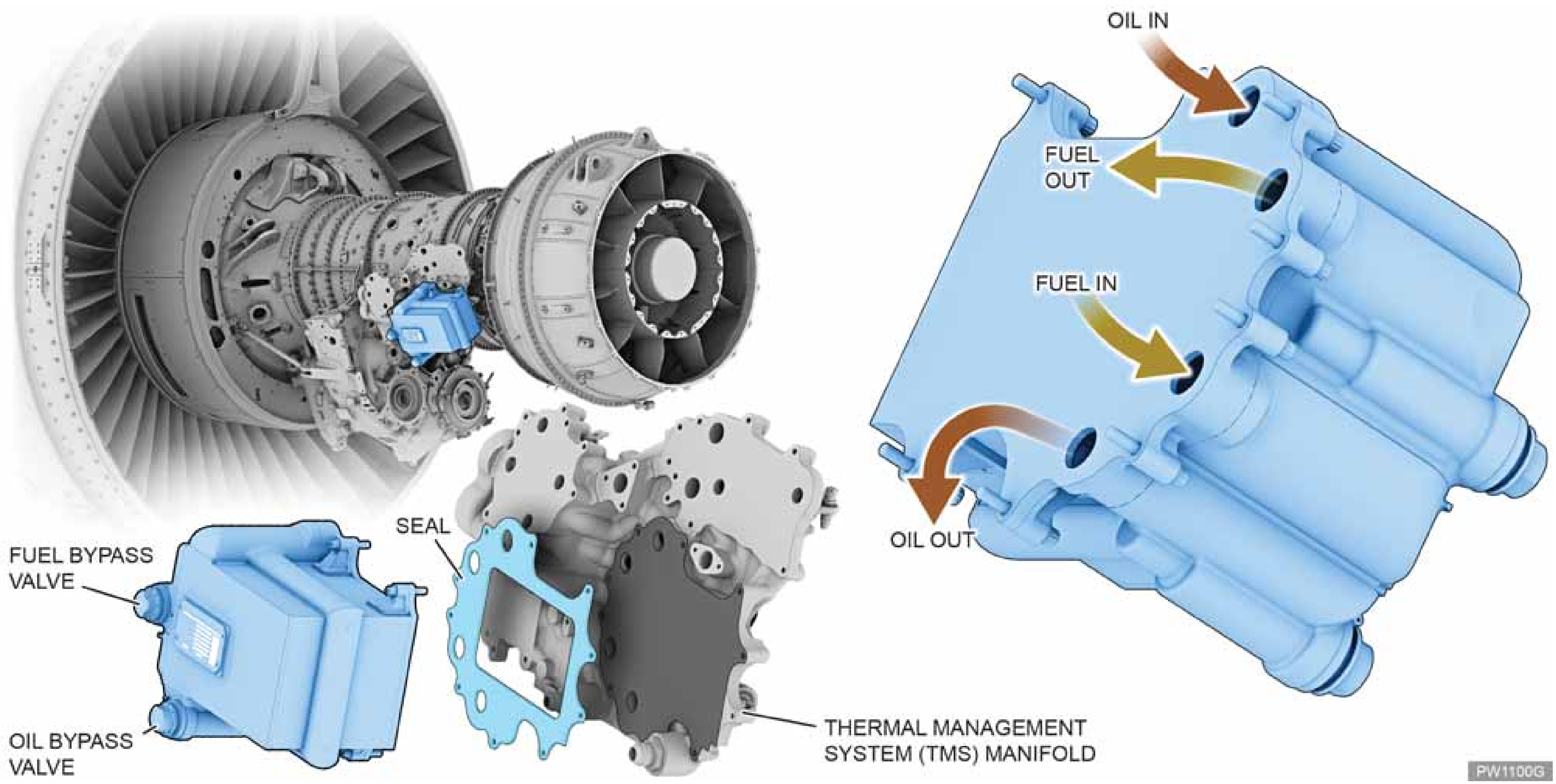
The FOHE is mounted to the Thermal Management System (TMS) manifold on the Turbine Intermediate Case at 9:00.

Description:

The Fuel/Oil Heat Exchanger has a stacked plate design that contains internal flow passages for fuel and oil. Made from aluminum due to its light weight and high thermal conductivity, the plates are stacked in alternating order and brazed together.

Operation:

1. During operation, heat transfers from the oil to the fuel as they circulate through the plates.
2. A passive oil bypass spring valve causes oil to bypass the FOHE if the oil side becomes clogged.
3. When incoming fuel pressure increases because of ice in the fuel, a spring-loaded valve will open and allow fuel to bypass the oil cooler.



DISTRIBUTION SYSTEM – FUEL/OIL HEAT EXCHANGER (FOHE)

DISTRIBUTION SYSTEM (Cont.)

Air/Oil Heat Exchanger (AOHE)

Purpose: LRU PMT

The Air/Oil Heat Exchanger uses fan air to cool the engine oil.

Location:

The assembly is attached to the engine at 11:00 next to the diffuser case.

Description:

The AOHE is a fin-and-plate type heat exchanger with a mechanical bypass valve. Inlet and exhaust ducts are attached to front and aft flanges of the exchanger. A constant flow of engine oil and cooling air passes through the exchanger during operation. The engine oil cooled by the AOHE reduces the amount of heat that must be transferred from the oil to the fuel in the FOHE.

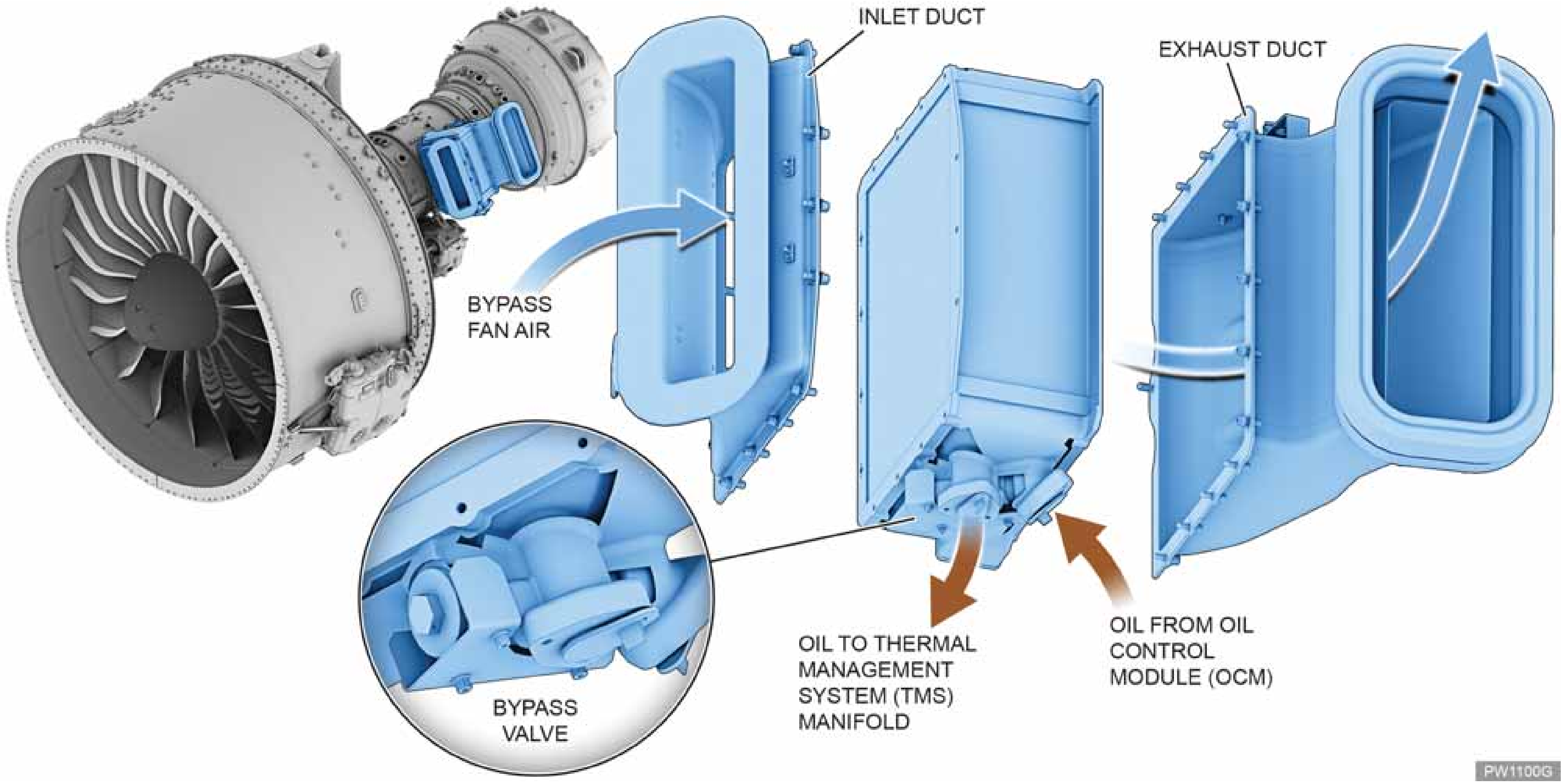
Oil flow through the AOHE is controlled by the FOHEBV.

Operation:

1. Fan bypass air is delivered to the inlet side of the AOHE through the inlet duct, then leaves through the exit duct into the bypass airflow. The cool fan air flows through thin aluminum fins and through aluminum plates with passageways.

2. The oil flows through the passageways in the aluminum plate, which transfers the heat to the fins. This heat is then transferred to the cool air.

A passive spring-and-valve oil bypass diverts oil around the AOHE if the oil side of the exchanger becomes clogged.



DISTRIBUTION SYSTEM – AIR/OIL HEAT EXCHANGER (AOHE)

DISTRIBUTION SYSTEM (Cont.)

IDG Oil/Oil Heat Exchanger (IDGOOHE)

Purpose: LRU PMT

The IDGOOHE uses engine oil to cool IDG oil.

Location:

The IDGOOHE is mounted to the Thermal Management System manifold at 9:00.

Description:

Proper temperature of IDG oil is critical for frequency control, as well as for lubrication of IDG bearings and gears. Heat is transferred from the IDG's self-contained, passive oil system to the oil/oil heat exchanger.

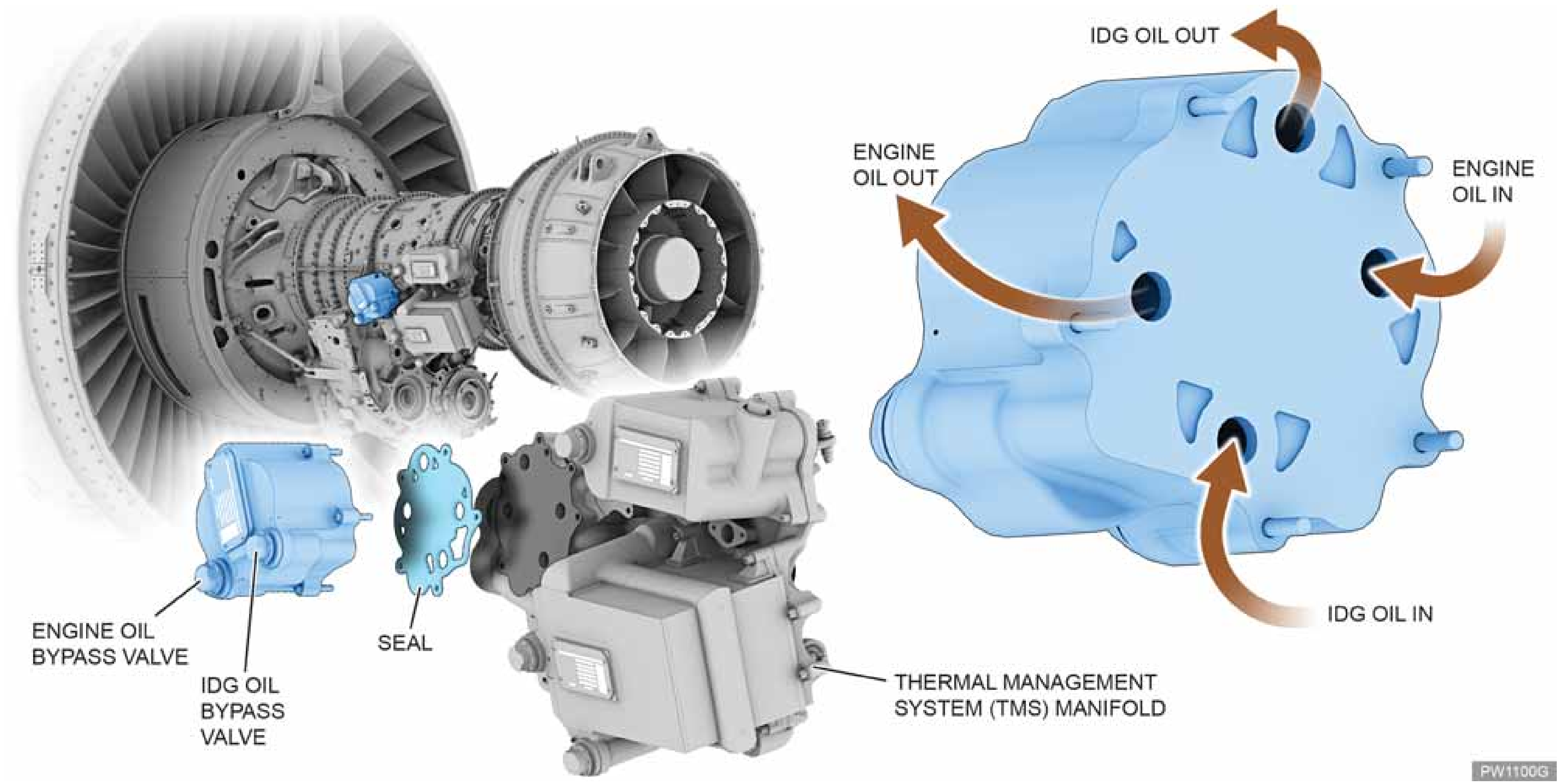
Operation:

In hot conditions, oil flows from the IDG to the core of the oil/oil heat exchanger, transferring heat. This usually occurs when the engine is at idle and the generator oil system is hotter than the engine oil system.

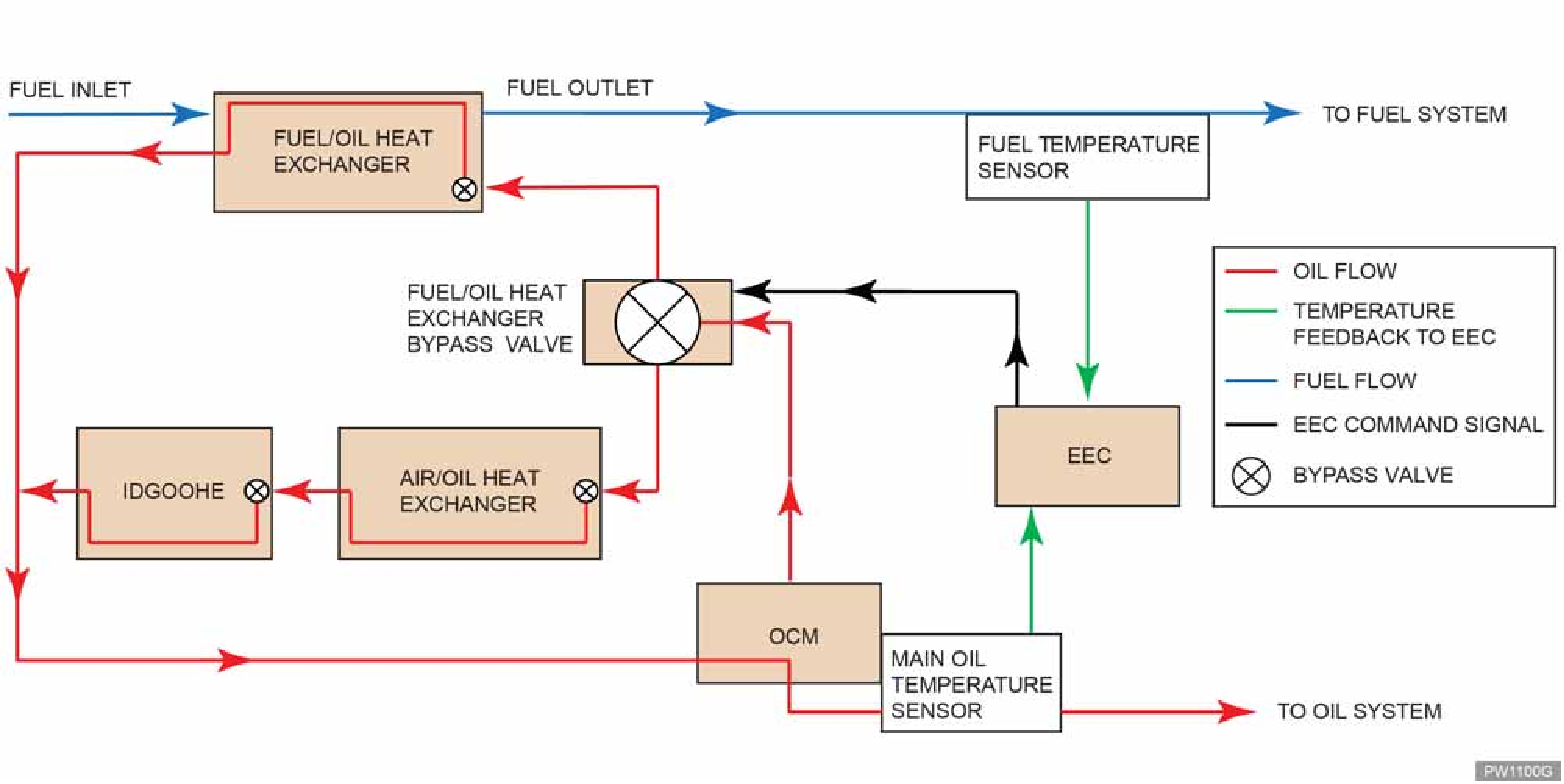
Safety Conditions

WARNING

WAIT 5 MINUTES MINIMUM TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE REMOVAL. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.



DISTRIBUTION SYSTEM – IDG OIL/OIL HEAT EXCHANGER (IDGOOHE)



DISTRIBUTION SYSTEM – HEAT EXCHANGERS

DISTRIBUTION SYSTEM (Cont.)

Active Oil Damper Valve (AODV)

Purpose:

LRU PMT

The AODV controls oil flow to the No. 3 Bearing damper.

Location:

The valve is located on the left side of the engine mounted to the bottom part of the OCM.

Description:

The AODV performs these functions:

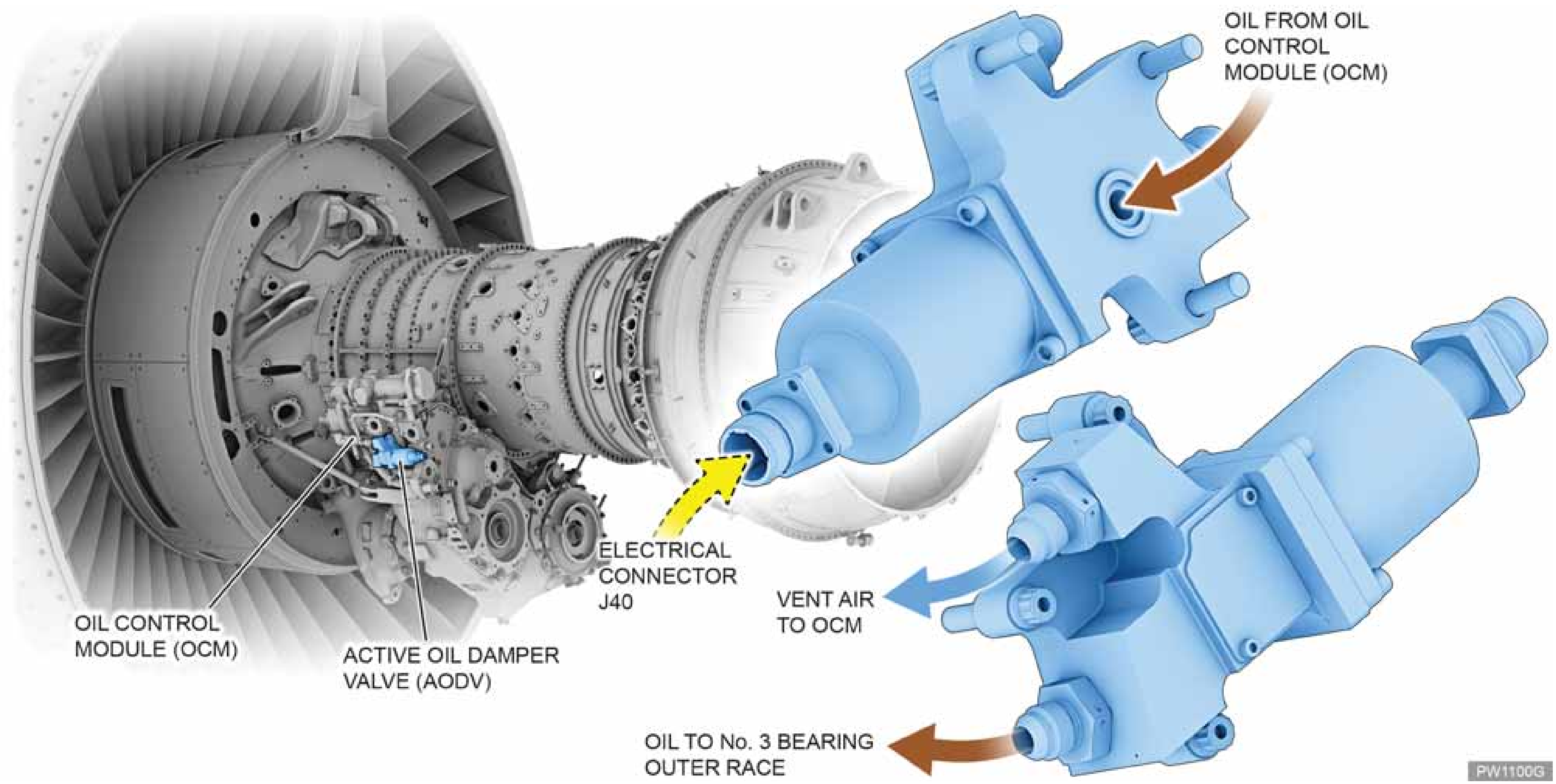
- limits high spool (N2) vibration
- optimizes No. 3 Bearing loads during all phases of operation
- provides bowed rotor protection at sub-idle.

Operation

The valve is a dual-coil solenoid scheduled on or off by either channel of the EEC. The valve will provide an open or closed position of damper oil flow when the engine is running. Valve positioning is a function of N2 speed.

See the chart for additional details.

N2 Rotor Speed	Damper Position	AODV Condition	Oil to No. 3 Damper
Start to idle	ON	De-energized	Flowing
Idle to take-off	OFF	Energized	No flow
Take-off	ON	De-energized	Flowing



DISTRIBUTION SYSTEM – ACTIVE OIL DAMPER VALVE (AODV)

DISTRIBUTION SYSTEM (Cont.)

Variable Oil Reduction Valve (VORV)

Purpose: LRU PMT

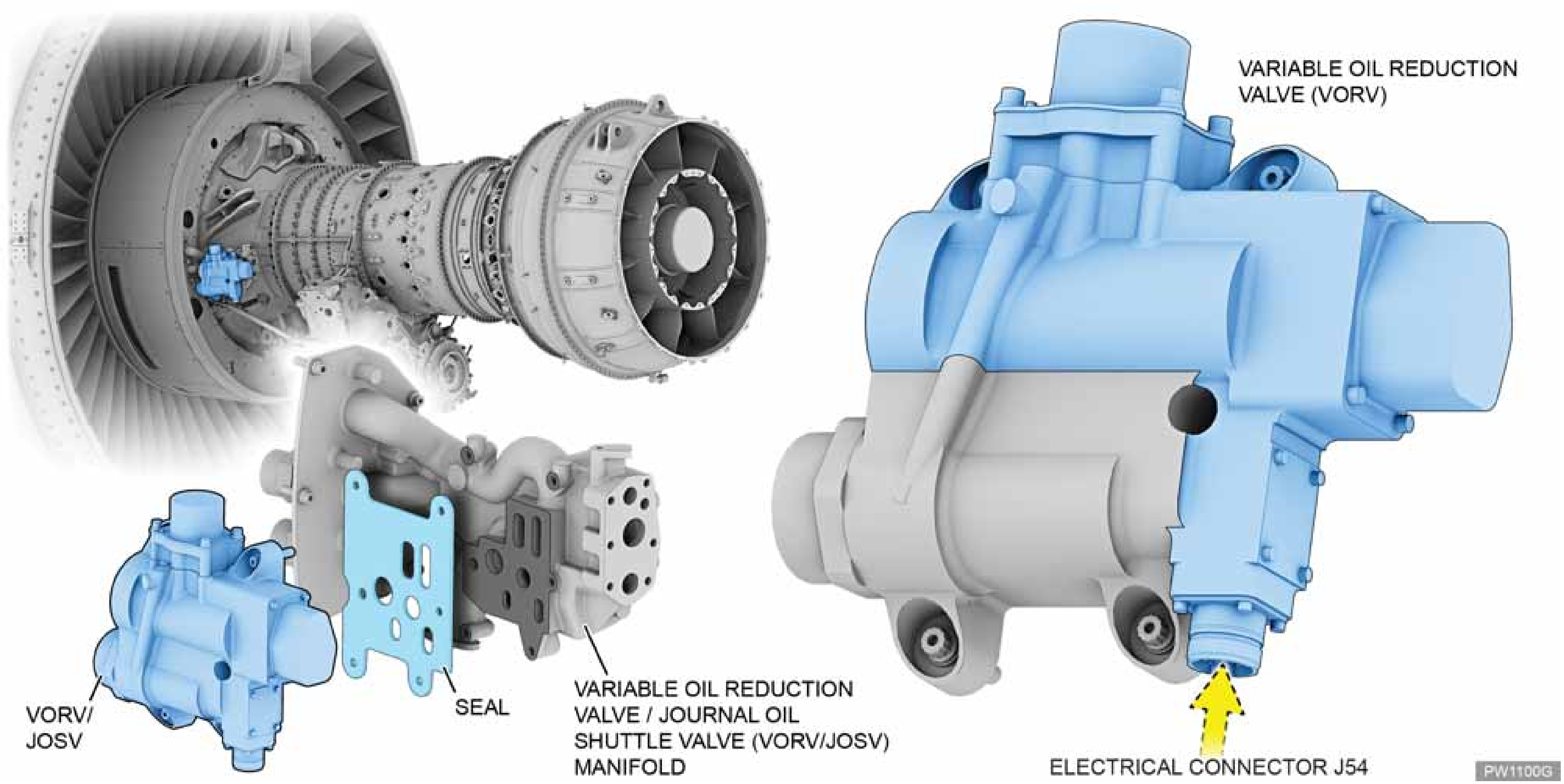
The Variable Oil Reduction Valve modulates oil flow to the Fan Drive Gear System and the No. 3 Bearing during cruise, when a lesser amount is required.

Location:

The VORV is located on the CIC firewall at 9:00.

Description:

The VORV is an electro-mechanical device controlled by the EEC. The valve is fully modulated by means of an Electro Hydraulic Servo Valve (EHSV). Valve position feedback to the EEC is provided by a Linear Variable Differential Transformer (LVDT).



DISTRIBUTION SYSTEM – VARIABLE OIL REDUCTION VALVE (VORV)

DISTRIBUTION SYSTEM (Cont.)

Journal Oil Shuttle Valve (JOSV)

Purpose: LRU PMT

The Journal Oil Shuttle Valve senses oil pressure to the FDGS journal bearings, and maintains a continuous supply of oil to the bearings under all conditions.

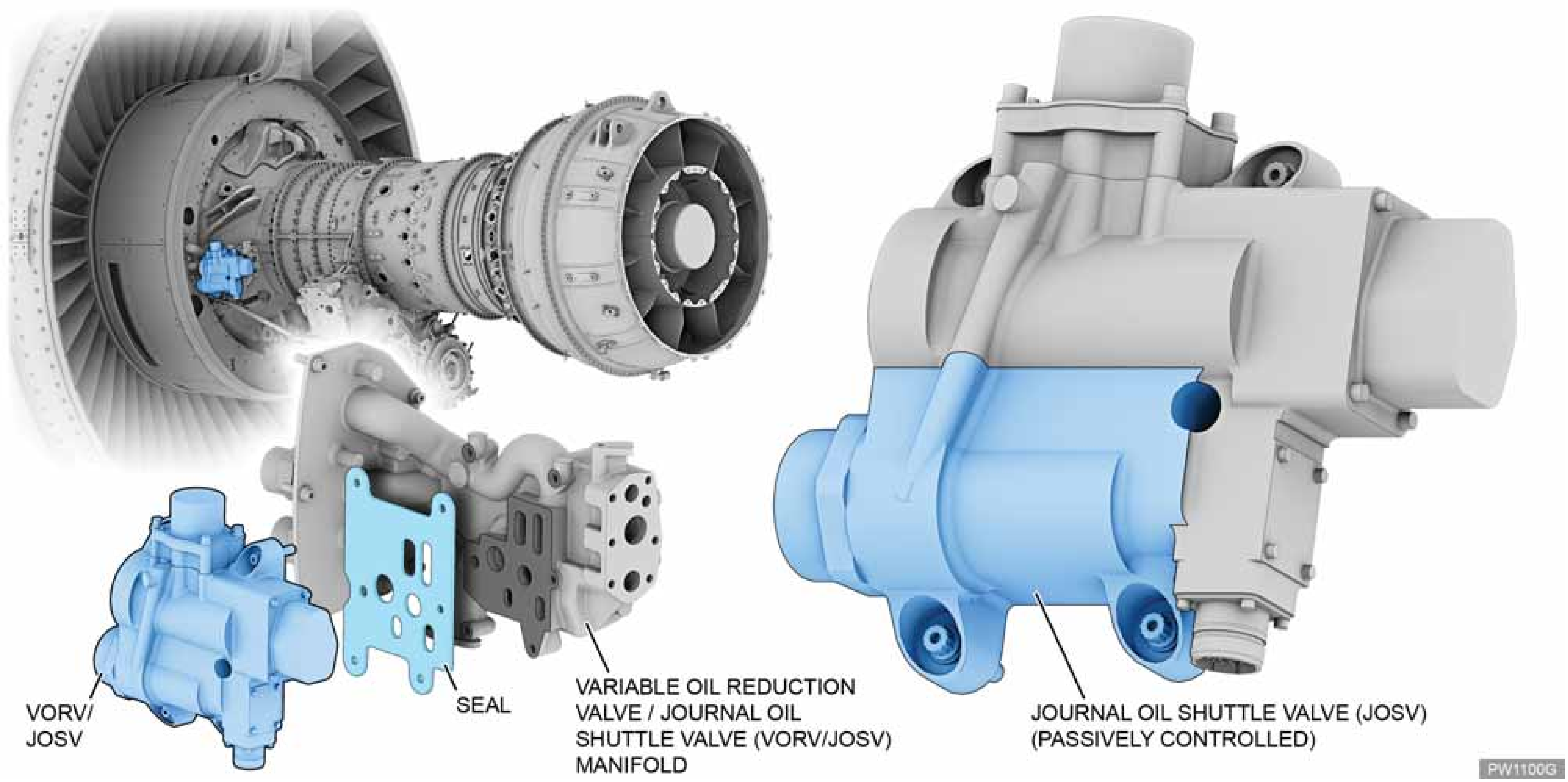
Location:

The JOSV is installed on the JOSV/VORV manifold located at 9:00 on the CIC firewall.

Description:

The JOSV is a mechanical, two-position device that directs oil flow from the main oil or emergency oil supply to the journal bearing.

The valve has no EEC control or feedback.



DISTRIBUTION SYSTEM – JOURNAL OIL SHUTTLE VALVE (JOSV)

DISTRIBUTION SYSTEM (Cont.)

Valve Operation

Variable Oil Reduction Valve (VORV)

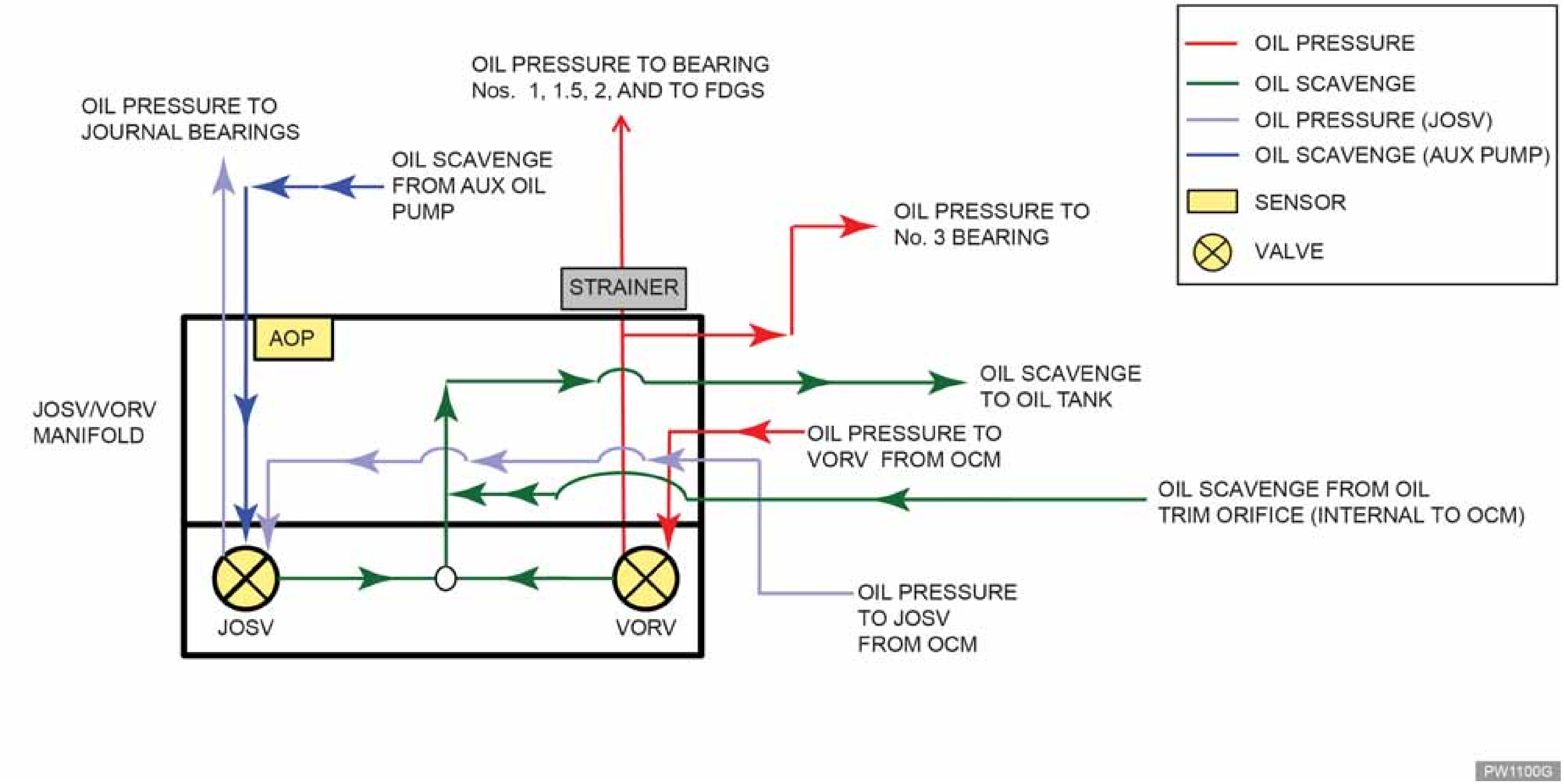
Maximum oil flow to lubricate the gear faces of the FDGS is required only at take-off. At cruise, oil flow through the VORV to the front and No. 3 Bearing compartments is reduced and sent back to the oil tank.

Less oil flowing to the gears reduces the oil heat load and increases fan drive gearbox efficiency. When in the fail safe position, the valve reverts to maximum oil flow.

Journal Oil Shuttle Valve (JOSV)

The JOSV is passively controlled by comparison of main oil pressure against gearbox vent pressure.

When oil pressure is normal, the primary oil goes to the journal bearings. If oil pressure decreases below design limits, the JOSV sends oil from the Auxiliary Lubrication System to the journal bearings.



DISTRIBUTION SYSTEM – VORV/JOSV OPERATION

DISTRIBUTION SYSTEM (Cont.)

Last Chance Oil Strainers

LRU PMT

Purpose:

Large particles can enter the oil supply beyond the main oil filter on the Oil Control Module. Last chance oil strainers prevent these particles from entering bearing compartments and clogging oil nozzles.

Location:

Strainer locations for bearing compartments and the Main Gearbox are shown at right.

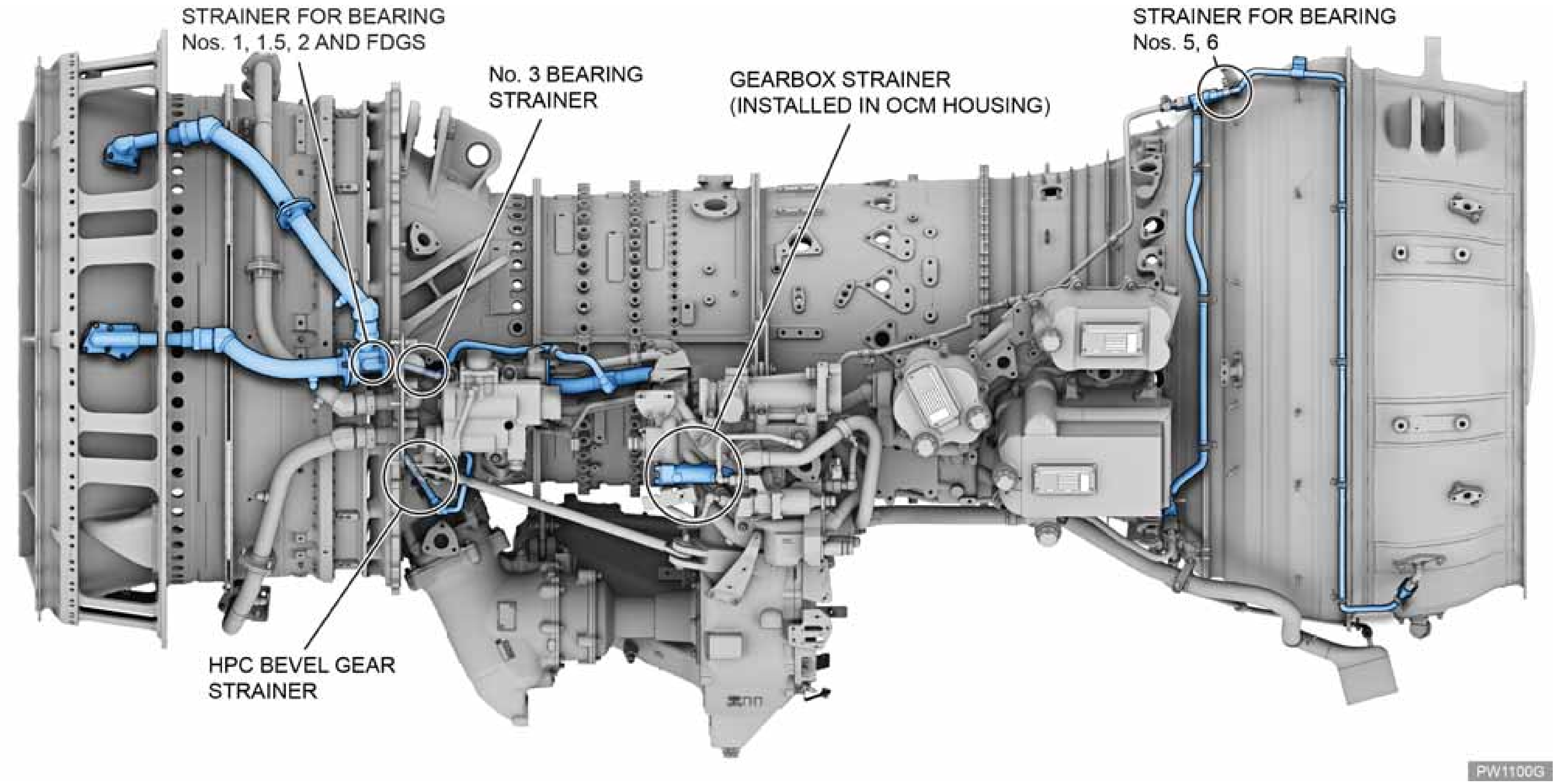
Description:

Strainers are a metal mesh type that fit inside the oil pressure supply tubes and are referred to as in-line strainers. They can be removed, inspected, cleaned and replaced during line maintenance, but this is not required under normal engine operation.

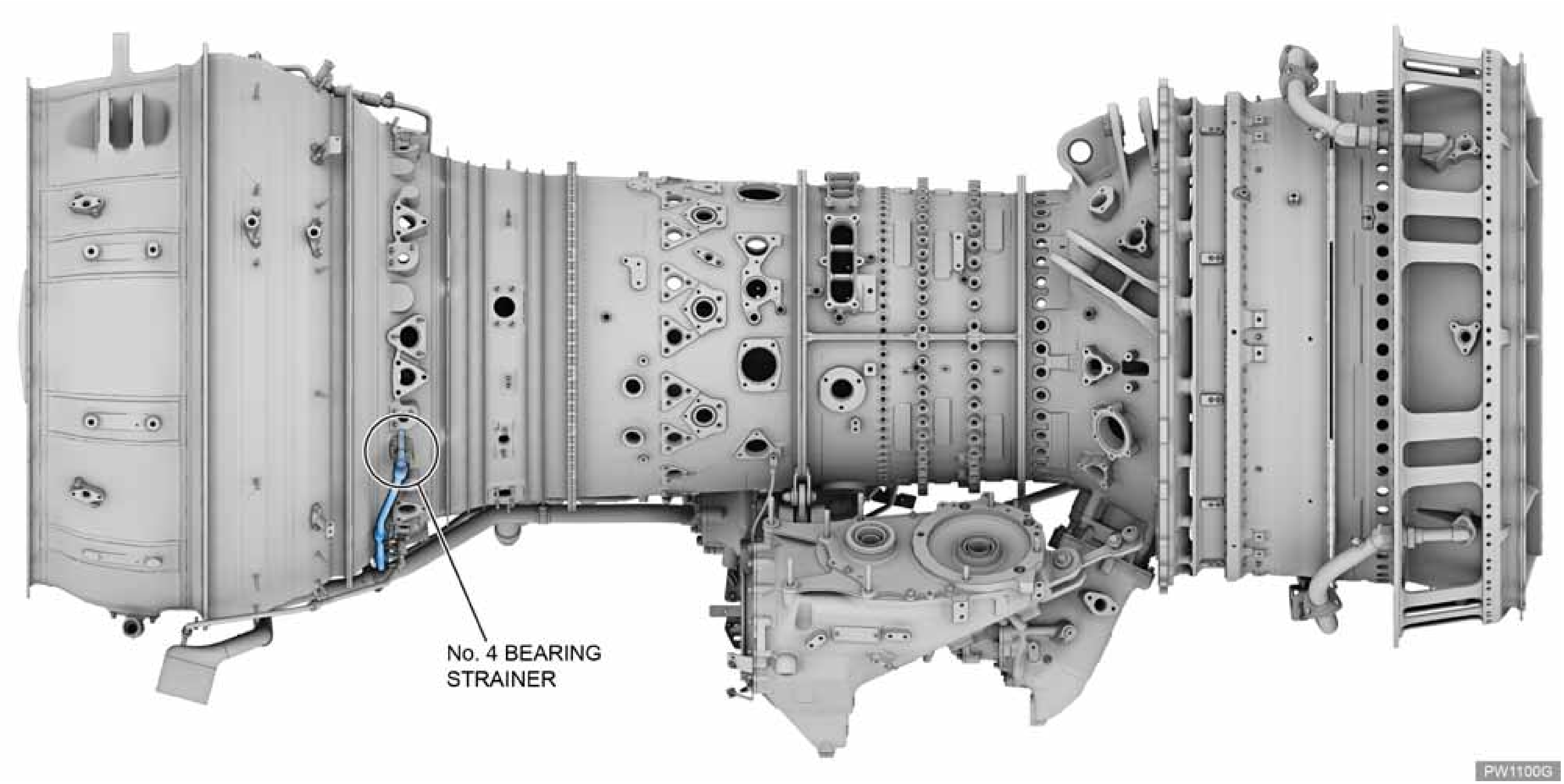
Component	Oil Strainer Location
Bearing nos. 1, 1.5, 2	Oil pressure tube for all three bearings
No. 3 Bearing	No. 3 Bearing oil pressure tube
No. 4 Bearing	No. 4 Bearing pressure tube
Bearing nos. 5 and 6	No. 5 Bearing oil pressure tube
Main Gearbox	Mounted to the OCM housing

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS

DISTRIBUTION SYSTEM – LAST CHANCE OIL STRAINER LOCATIONS



DISTRIBUTION SYSTEM – LAST CHANCE OIL STRAINER LOCATIONS (LEFT SIDE)



DISTRIBUTION SYSTEM – LAST CHANCE OIL STRAINER LOCATIONS (RIGHT SIDE)

DISTRIBUTION SYSTEM (Cont.)

Oil Flow Summary

Oil flow through the engine is described below.

1. Oil flows from the oil tank to the Lubrication and Scavenge Oil Pump (LSOP). The pump pressurizes the oil and sends it through the main oil filter and on to the OCM.

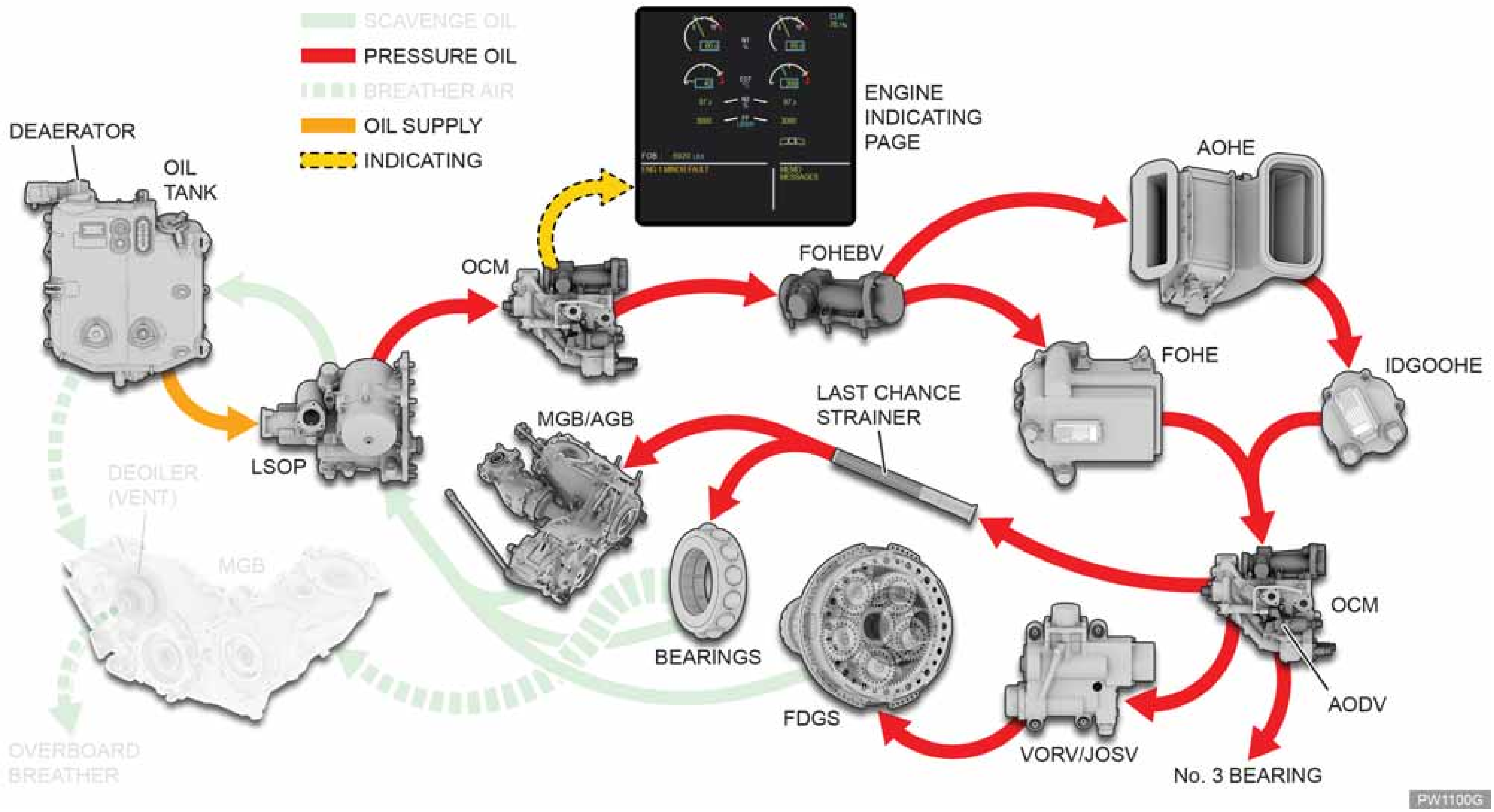
2. Filtered oil then goes to the Fuel/Oil Heat Exchanger Bypass Valve (FOHEBV). The modulating bypass valve is controlled by FADEC. The valve distributes the oil between the FOHE and/or the AOHE. Oil sent to the AOHE will also go through the IDGOOHE, which cools IDG oil.

3. All the cooled oil then returns to the OCM to be distributed to the engine main bearings, the FDGS, journal bearings, the gearboxes, and the Permanent Magnet Alternator (PMA).

   Only cooled oil is supplied to the FDGS journal bearings. A mix of cooled and uncooled oil flows to all other bearings and gears.

4. Nozzles in the main bearing compartments and gearboxes supply the oil at correct flow rates to bearings, seals, gears, and accessory drive splines. Last chance strainers are provided at the entrance to compartments, protecting the oil nozzles from debris.

5. An AODV controlled by the EEC provides oil to the No. 3 Bearing damper system on an ON/OFF schedule.



DISTRIBUTION SYSTEM OIL FLOW

DISTRIBUTION SYSTEM (Cont.)

Auxiliary Lubrication System

The Auxiliary Lubrication System protects the FDGS journal bearings from low oil pressure conditions that could cause damage. These include windmill operations (in flight or on the ground) and negative-G events.

The system is located on the support housing for bearing nos. 1/1.5 and consists of the following components:

- fan drive gear train
- windmill/auxiliary pump
- sprag clutch gear assembly
- auxiliary oil reservoir.

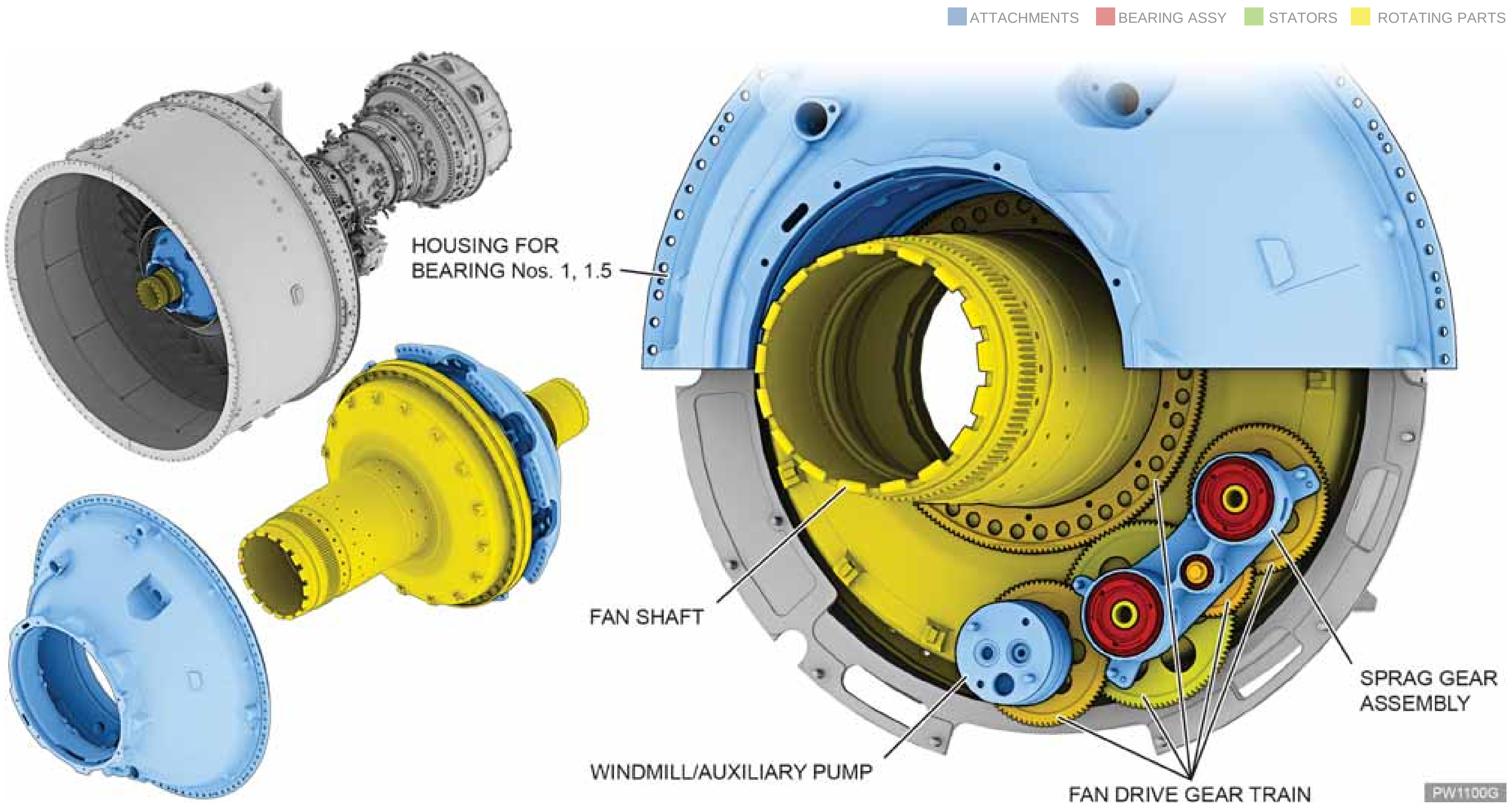
The dedicated windmill/auxiliary dual-stage fan oil pump is located in the front bearing compartment and driven by the fan rotor. The pump continuously draws oil from a dedicated auxiliary reservoir and compartment sump located in the front bearing compartment. The auxiliary reservoir is part of the casting of the support for bearing nos. 1/1.5.

The AOPS provides an auxiliary oil pressure signal to the EEC. In case of pump failure, the EEC generates a message alerting the crew.

In normal conditions the pump sends the reservoir and sump oil to the Journal Oil Shuttle Valve (JOSV), which directs the oil back to the oil tank. In low pressure conditions the JOSV directs the oil to journal bearings, ensuring their lubrication.

During negative-G events, the pump draws oil from the auxiliary reservoir, which is continuously replenished by oil slung from the gear system into the reservoir.

During windmill operations, the pump draws oil through the compartment sump, which is continually replenished by oil cast off from the gear system and main shaft bearings. The sprag clutch gear assembly keeps the dual-stage pump gear turning in the same direction, regardless of the direction in which the fan is turning.



DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM

DISTRIBUTION SYSTEM

Auxiliary Lubrication System (Cont.)

Fan Drive Gear Train

Purpose:

The fan drive gear train is a system of gears that ensures the windmill/auxiliary pump is protected from reverse windmill conditions.

Location:

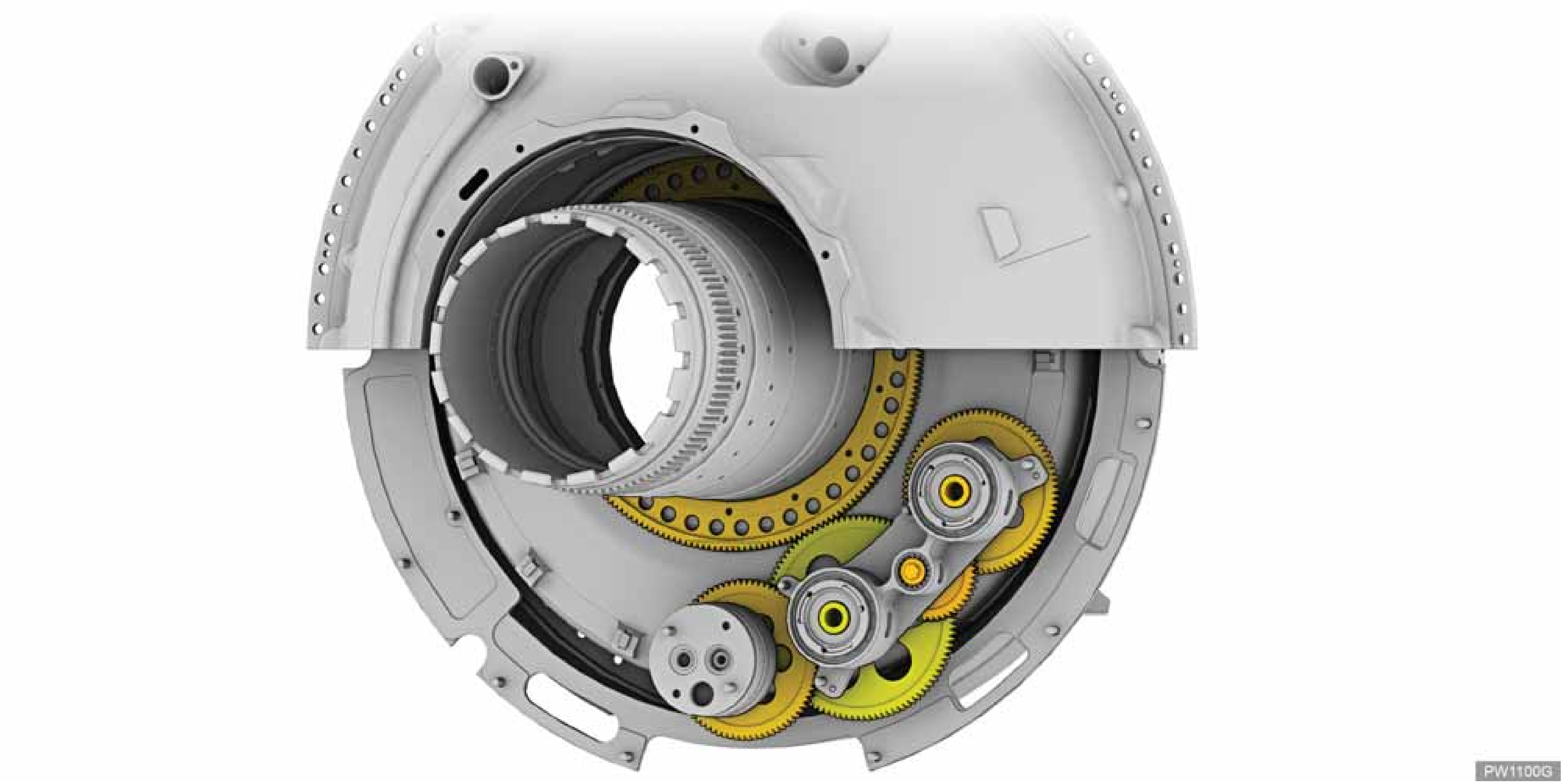
The fan drive gear train is located inside the support for bearing nos. 1/1.5 and on the fan shaft.

Description:

The fan drive gear train connects the windmill/auxiliary pump to the fan shaft. Whenever the fan is turning, the windmill/auxiliary pump is sending oil to the FDGS journal bearing operation.

Torque transfers from the fan shaft gear through the fan drive gear train. Torque is transferred next to the windmill/auxiliary pump gear, and to the pump itself through a splined shaft.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM – FAN DRIVE GEAR TRAIN

DISTRIBUTION SYSTEM

Auxiliary Lubrication System (Cont.)

Windmill/Auxiliary Pump

Purpose:

The windmill/auxiliary pump is a dedicated dual-stage fan oil pump that supplies oil to journal bearings during low-pressure oil conditions.

Location:

The pump is located on the support for bearing nos. 1 and 1.5.

Description:

The pump consists of two stages with separate feeds and a common discharge. One stage feed is connected to the auxiliary oil reservoir in the support for bearing nos. 1 and 1.5. The other stage feed is connected to the auxiliary oil reservoir in the bottom, or sump, of the bearing compartment.

Operation:

See the chart for a summary of oil flow in various operating conditions.

Operating Condition	Oil Drawn From	Oil Sent To
Normal	Windmill/auxiliary pump	Oil tank
Negative gravity	Auxiliary reservoir	Journal bearings
Windmill	Sump	

In normal conditions when the Lubrication and Scavenge Oil Pump pressure supplies the FDG bearings sufficiently, oil from the windmill/auxiliary pump is directed back to the main oil tank by the JOSV.

In low oil pressure conditions, such as negative-G events, the pump stage connected to the auxiliary reservoir pumps oil to the journal bearings through the JOSV.

Under windmill conditions, oil from the sump stage is pumped by the windmill/auxiliary pump to the journal bearings through the JOSV.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS

DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM – WINDMILL/AUXILIARY PUMP

DISTRIBUTION SYSTEM

Auxiliary Lubrication System (Cont.)

Sprag Clutch Gear Assembly

Purpose:

The sprag clutch gear assembly keeps the auxiliary oil pump gear turning in the same direction during windmill conditions, regardless of the direction in which the fan shaft turns.

Location:

The assembly is mounted at 7:00 inside the support housing for bearing nos. 1 and 1.5.

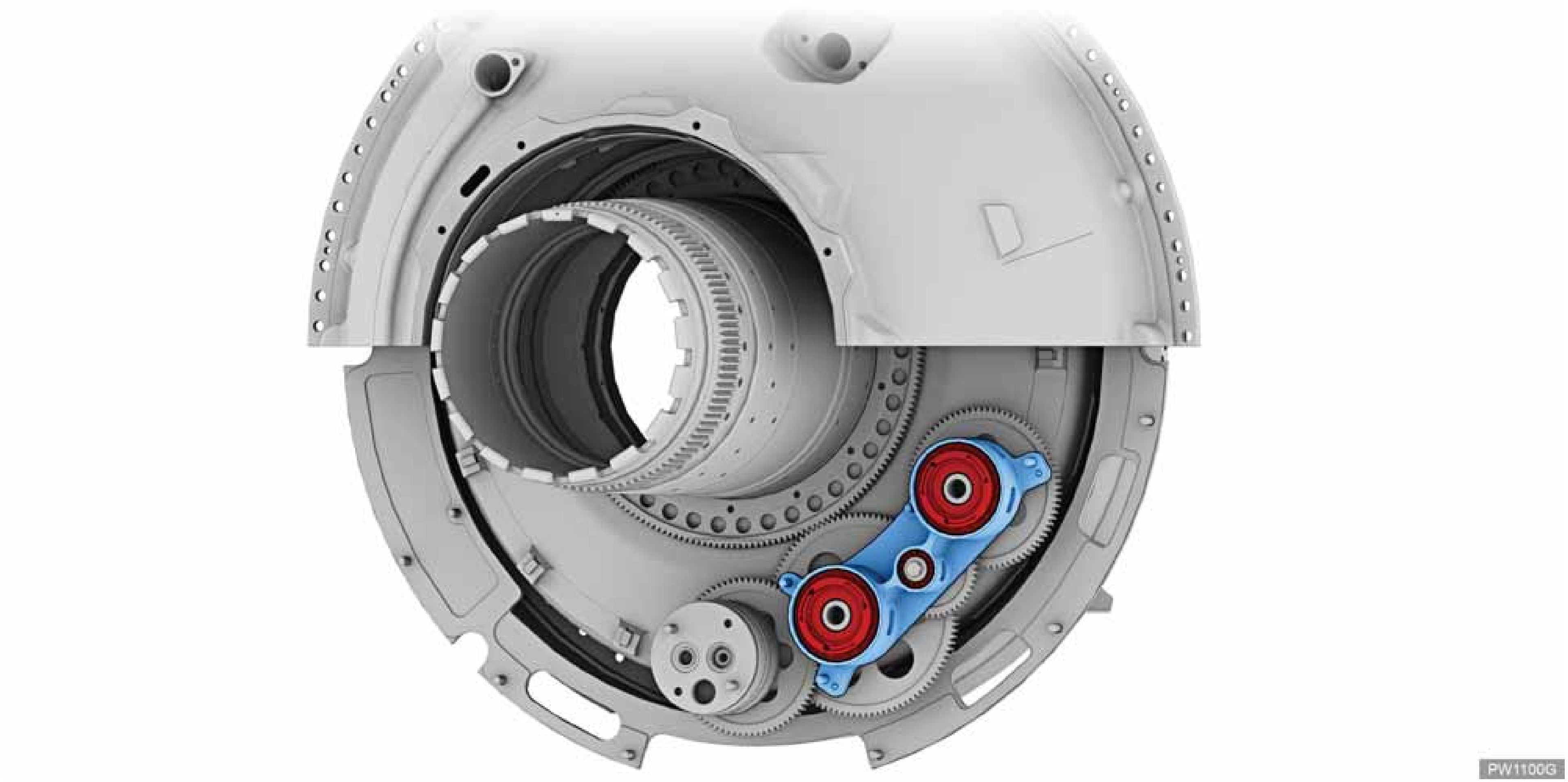
Description:

The sprag gear clutch assembly consists of a steel housing, two sprag clutch bearings and one roller bearing.

Operation:

All three bearings are pressed onto shafts turning spur gears that mesh with each other.

ATTACHMENTS BEARING ASSY STATORS ROTATING PARTS



DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM – SPRAG CLUTCH GEAR

DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM OPERATION

DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM OPERATION

DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM OPERATION

DISTRIBUTION SYSTEM

Auxiliary Lubrication System (Cont.)

Auxiliary Oil Reservoir

Purpose:

Oil in this reservoir is directed to journal bearings during negative-G events.

Location:

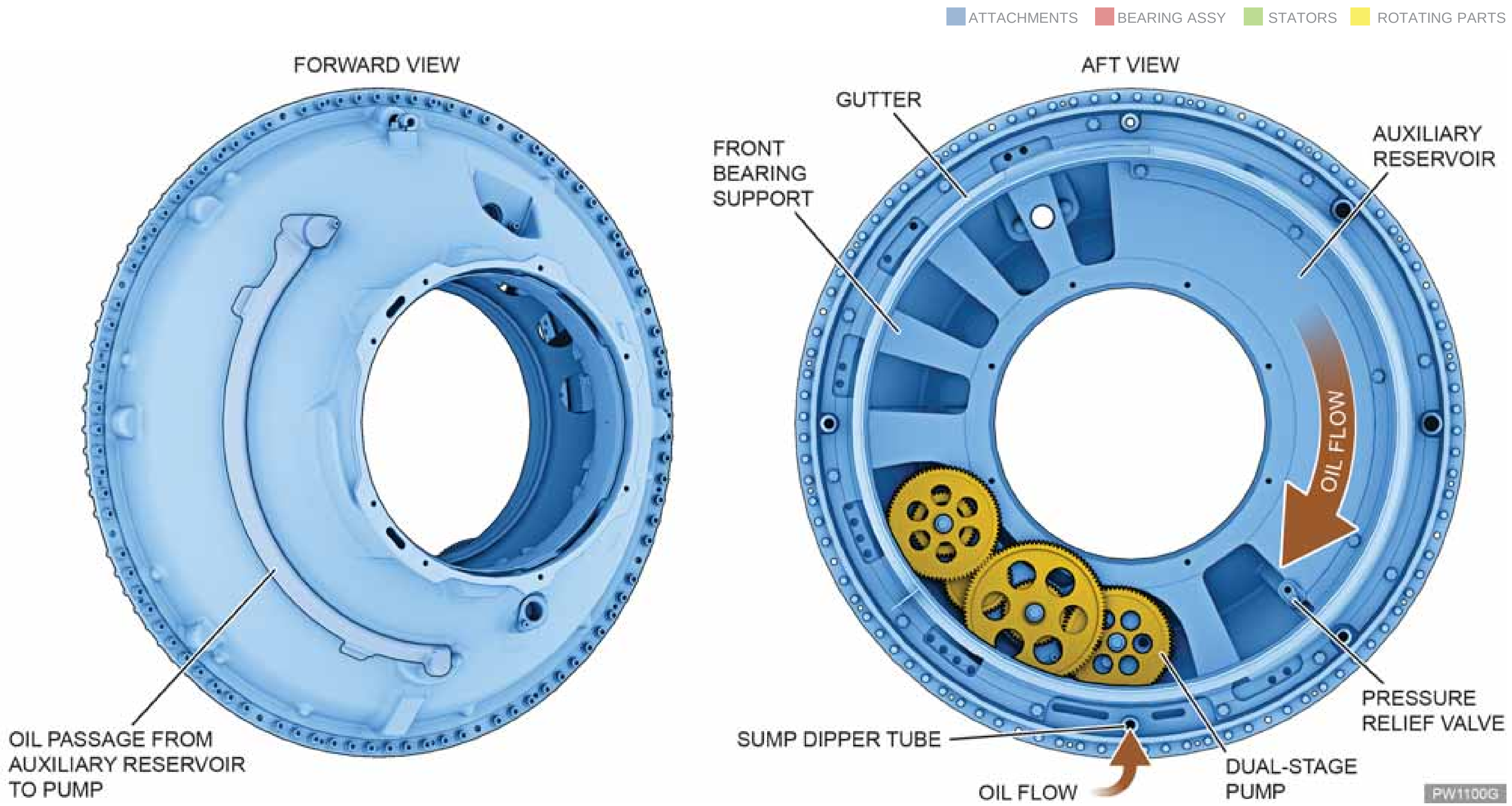
The reservoir is located in the compartment for bearing nos. 1 and 1.5.

Description:

Centrifugal action of the ring gear set drives oil into the gutter and then into the auxiliary oil reservoir.

Operation:

Oil is directed out of the reservoir to the auxiliary oil pump and to the journal bearings through passageways cast into the bearing support.



DISTRIBUTION SYSTEM – AUXILIARY LUBRICATION SYSTEM – AUXILIARY OIL RESERVOIR

SCAVENGE SYSTEM

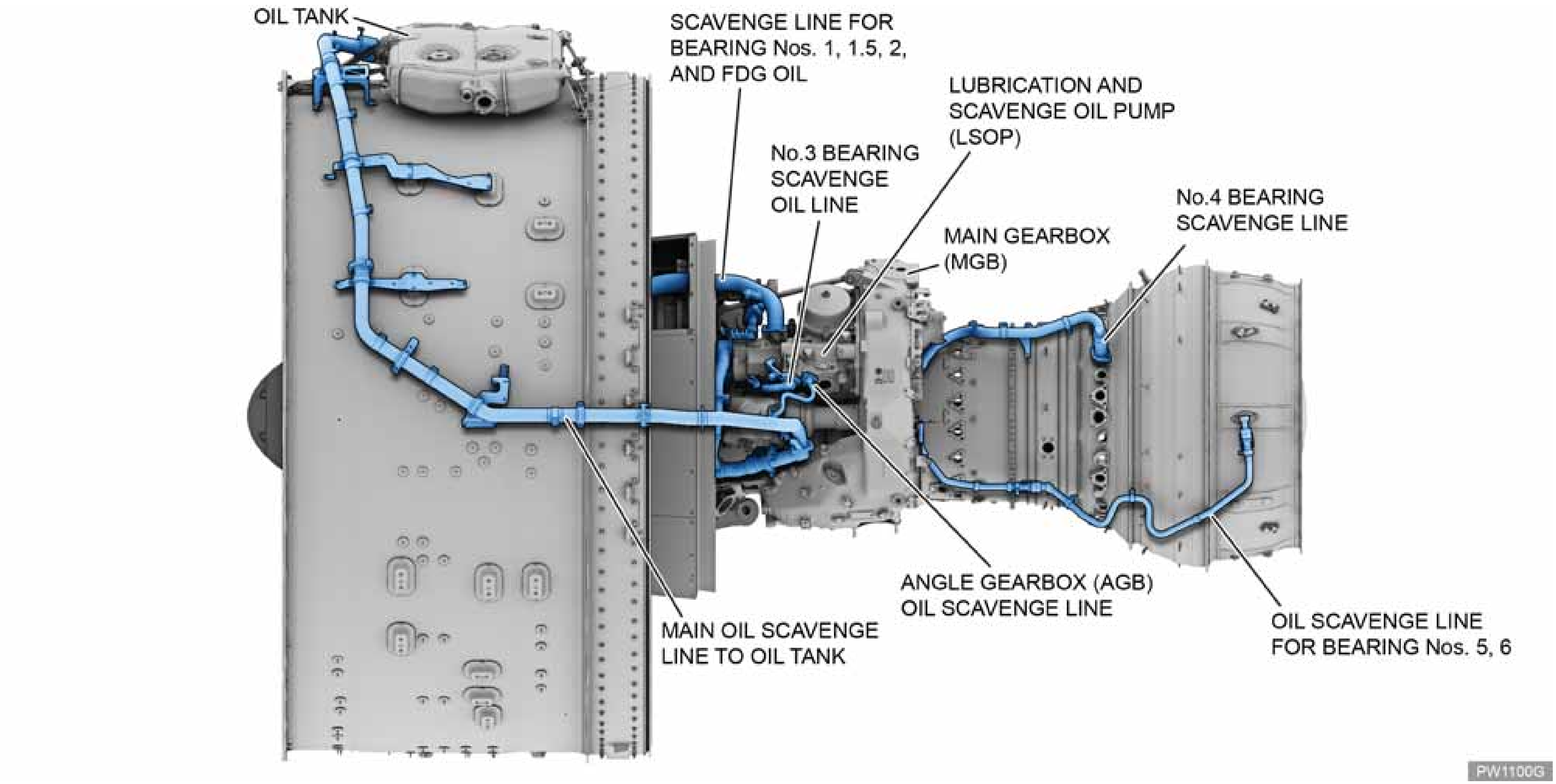
The Scavenge System pumps the hot oil scavenged from the bearing compartments and gearboxes back to the oil tank.

The system consists of a Lubrication and Oil Scavenge Pump (LSOP) .The pump has six stages that return oil from the areas listed below.

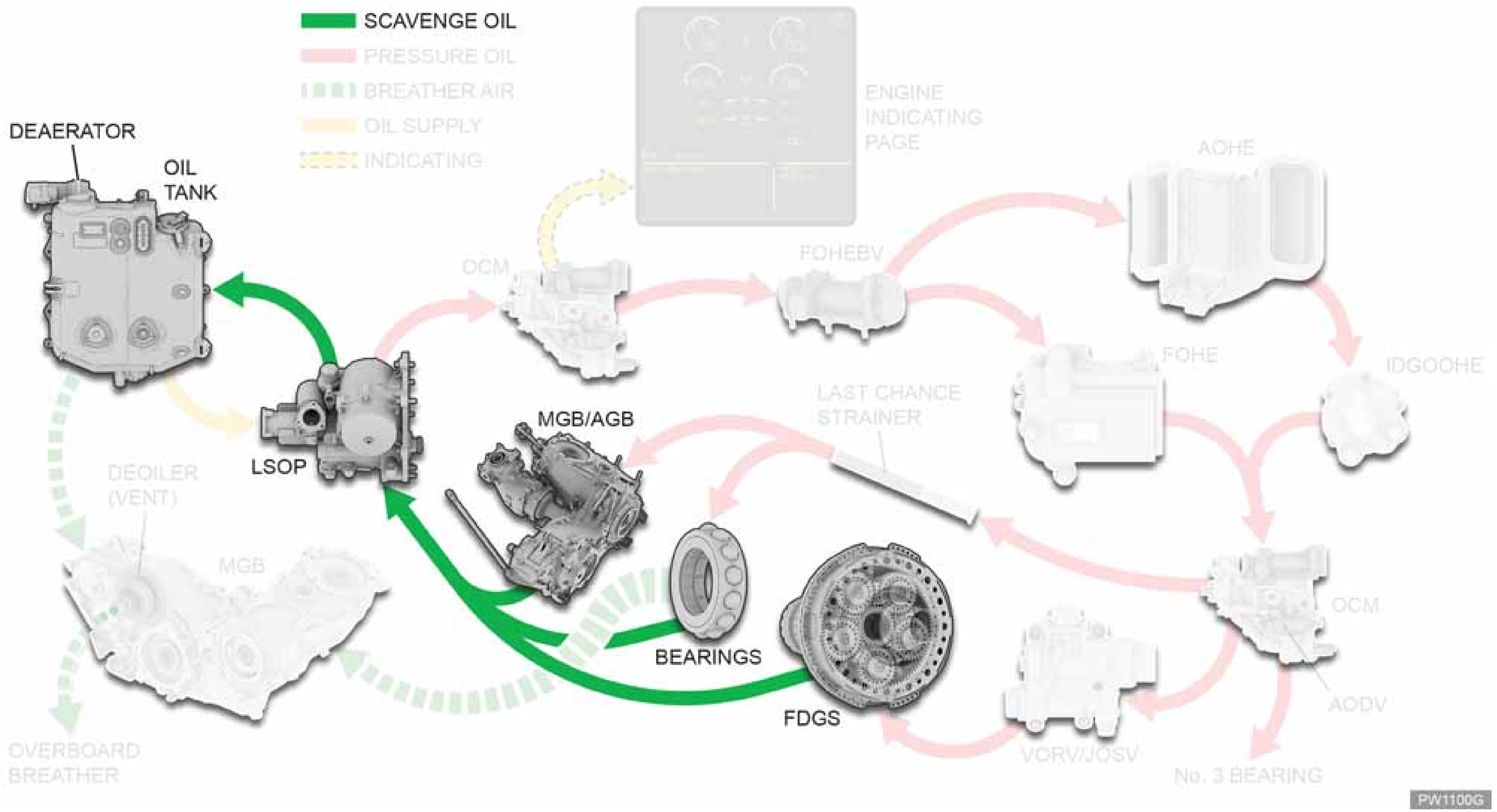
- Front bearing compartment servicing the FDGS and bearing nos. 1, 1.5 and 2
- No. 3 Bearing compartment
- No. 4 Bearing compartment
- Compartment for bearing nos. 5 and 6
- Main Gearbox MGB
- Angle Gearbox AGB

The stages send scavenged oil to the oil tank, where a deaerator separates the air that has mixed with the oil. Air that is separated from the oil pressurizes the oil tank. Note that the Main Gearbox requires no external scavenge line.

The system has five magnetic chip collectors located on the LSOP. A sixth magnetic chip collector for the No.4 Bearing compartment is located on the No.4 Bearing compartment scavenge line.



SCAVENGE SYSTEM (BOTTOM VIEW)



SCAVENGE SYSTEM OIL FLOW

SCAVENGE SYSTEM (Cont.)

Magnetic Chip Collectors

LRU PMT

Purpose:

The Lubrication and Scavenge Oil Pump has six magnetic chip collectors. The collectors catch ferrous metal particles in the scavenge oil, which are used to diagnose system problems.

Location:

Five of the collectors are located on the LSOP and a sixth is found on the No. 4 Bearing scavenge return tube.

Each area listed below has its own collector.

- Front bearing compartment, servicing the FDGS and bearing nos. 1/1.5 and 2
- No. 3 Bearing compartment
- No. 4 Bearing compartment
- Compartment for bearing nos. 5 and 6
- Main Gearbox
- Angle Gearbox

Safety Conditions

WARNING

WAIT 5 MINUTES MINIMUM TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE DOING THE REMOVAL PROCEDURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

YOU MUST REMOVE THE COLLECTOR PROBE BEFORE YOU REMOVE THE REMAINDER OF THE ASSEMBLY. DO NOT REMOVE THE COLLECTOR ASSEMBLY IN ONE STEP. IF YOU DO NOT OBEY THIS CAUTION, DAMAGE TO THE ASSEMBLY CAN OCCUR.

YOU MUST INSTALL THE MAGNETIC PROBE AFTER YOU INSTALL THE REMAINDER OF THE ASSEMBLY. DO NOT INSTALL THE MAGNETIC CHIP COLLECTOR AS A COMPLETE ASSEMBLY. IF YOU DO NOT OBEY THIS CAUTION, DAMAGE TO THE ASSEMBLY CAN OCCUR.

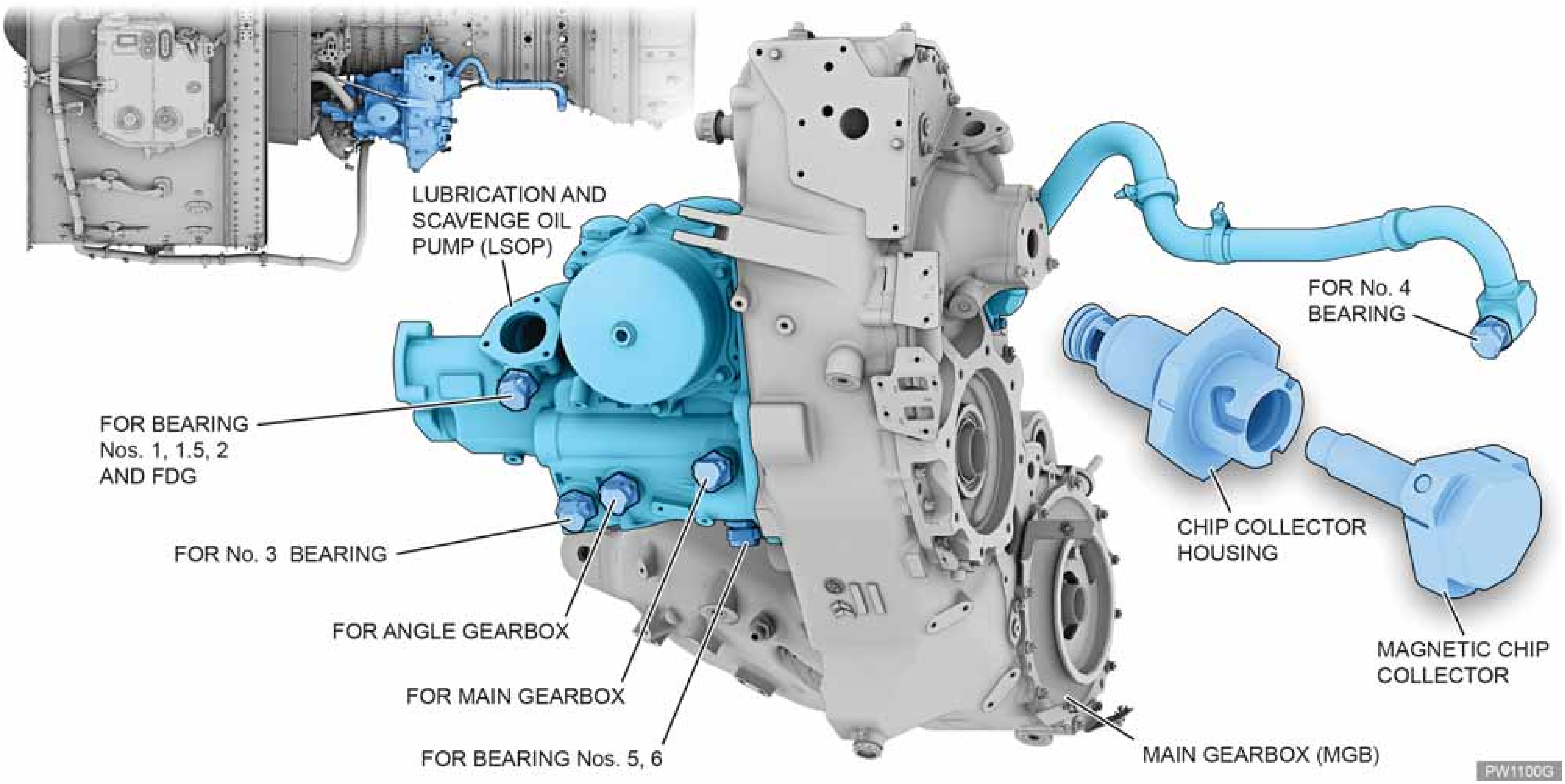
Description:

The collector assembly consists of a collector probe and probe housing. The probe housing has a spring-loaded check valve so there is no leakage when a detector is removed.

The six chip collectors are bayonet-type plugs that can be removed and examined at regular intervals or on-condition.

Operation:

When the probe is inserted to the housing, the check valve is forced open, exposing the probe tip to the oil flow. When the probe is removed for inspection the check valve closes, preventing oil from leaking out of the system.



SCAVENGE SYSTEM – MAGNETIC CHIP COLLECTOR LOCATIONS

BREATHER SYSTEM

During engine operation, sealing air flows into the bearing compartments. The sealing air must be vented to allow a continuous flow. The Breather System removes air from the bearing compartments, separates breather air from oil, and vents the air overboard. The vented sealing air is referred to as *breather air*.

Components are shown below.

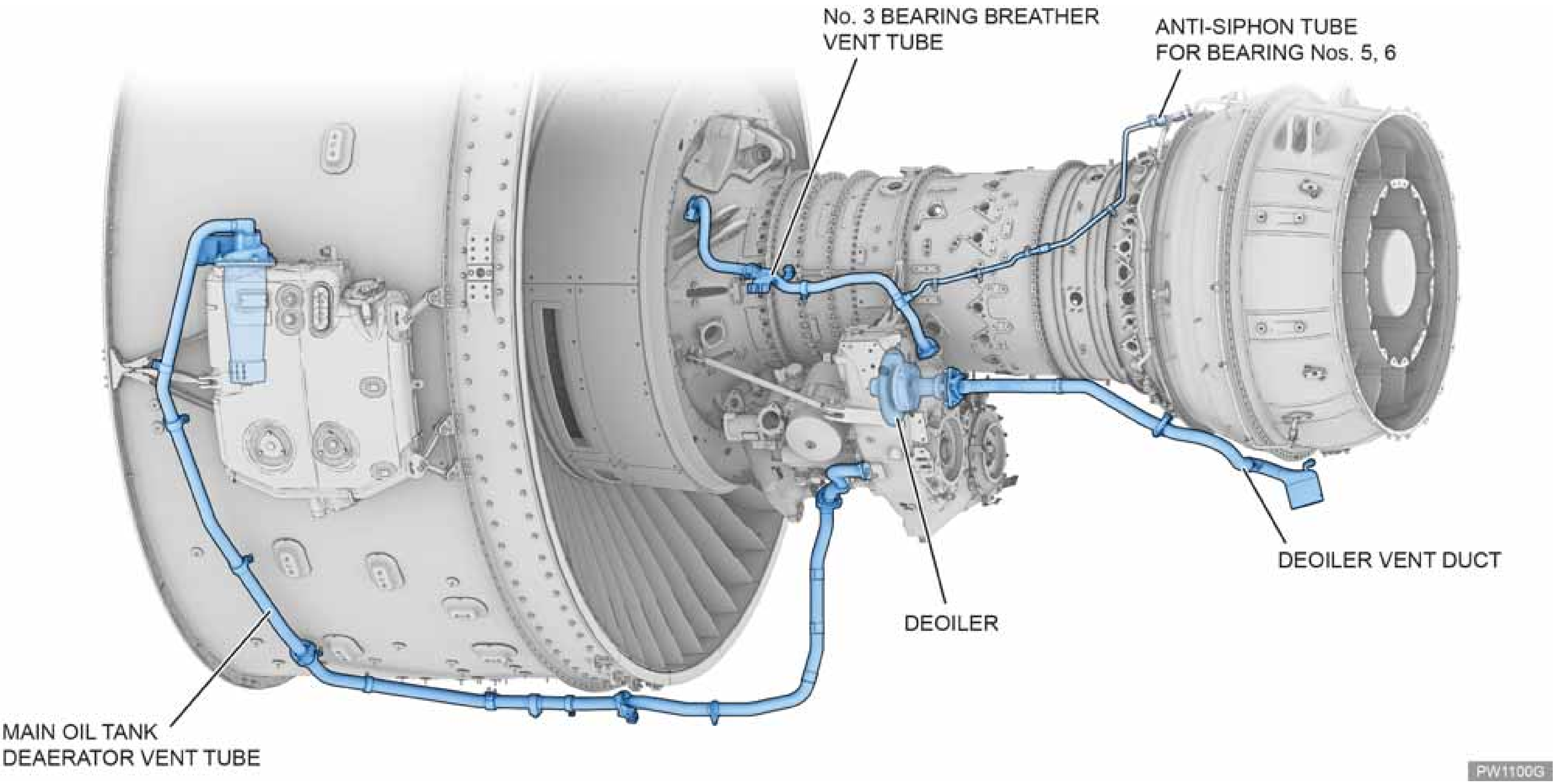
- Deoiler and deoiler vent duct
- Deoiler drive oil seal
- No. 3 Bearing breather vent tube
- Main oil tank deaerator vent tube
- Anti-siphon tube for bearing nos. 5 and 6

The No. 3 Bearing compartment has a dedicated breather vent tube that vents the breather air directly to the deoiler in the Main Gearbox (MGB). The breather air flows to the deoiler as a mist of air and oil. The deoiler separates the oil from the air, returning the oil to the engine and sending the air overboard through the deoiler vent.

Sealing air in the other bearing compartments mixes with scavenged oil and flows back to the oil tank. A static deaerator in the tank separates the oil from the air. The released air pressurizes the tank. The pressure in the tank is controlled by a spring-loaded-closed, mechanical poppet valve. The valve opens to release excess pressure in the tank and sends the excess air/oil mist to the deoiler.

Breather air from the MGB flows internally from gearbox to the deoiler vent tube.

The system also includes an anti-siphon break, which is a small, internal passage between the oil supply tube for bearing nos. 5–6 and the scavenge tube on top of the oil tank. At engine shutdown, the anti-siphon break interrupts the supply flow from the tube. This “break” in the flow allows oil to remain in the supply tube, which prevents coking.



BREATHER SYSTEM – COMPONENTS

BREATHER SYSTEM (Cont.)

Deoiler and Deoiler Vent Duct

Purpose:

The deoiler separates air from scavenge oil, returning the oil to the engine and sending the air overboard through the deoiler vent duct.

Location:

The deoiler is integral to the Main Gearbox and is located on the left side.

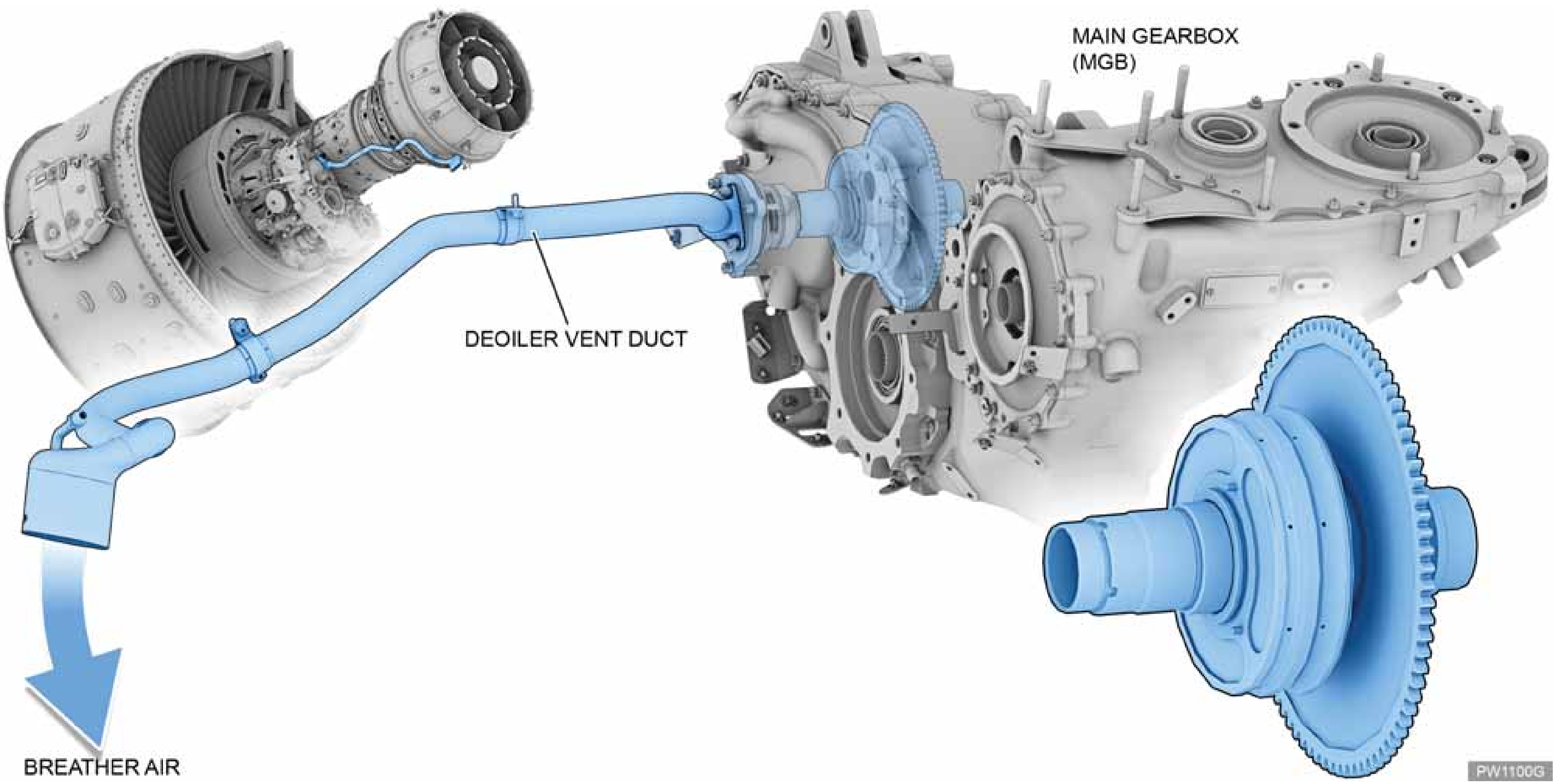
Description:

The deoiler is a centrifugal flow impeller that uses high rotational speed to separate heavier oil from the breather air.

Operation:

Torque is applied to the deoiler rotor drive gear from the MGB. The rotor captures oil mist residing in the MGB, and through centrifugal action the oil is separated from the air. The oil-soaked breather air is vented into the MGB from the No. 3 compartment and the oil tank.

The separated oil flows into the MGB sump to the LSOP, and the air flows out of the MGB through the deoiler vent duct.



BREATHER SYSTEM – DEOILER (AFT VIEW)

BREATHER SYSTEM (Cont.)

Deoiler Drive Oil Seal

LRU

Purpose:

The deoiler drive oil seal creates a seal between the deoiler shaft and the Main Gearbox (MGB).

Location:

The seal is located at the breather duct pad on the MGB.

Description:

The seal housing assembly is held in place by a retaining ring and has a puller groove used to remove the assembly. The runner is installed on the deoiler drive shaft.

The seal runner and carbon seal are replaced together. Packings are used between the seal housing and MGB housing and between the runner and drive shaft.

Safety Conditions

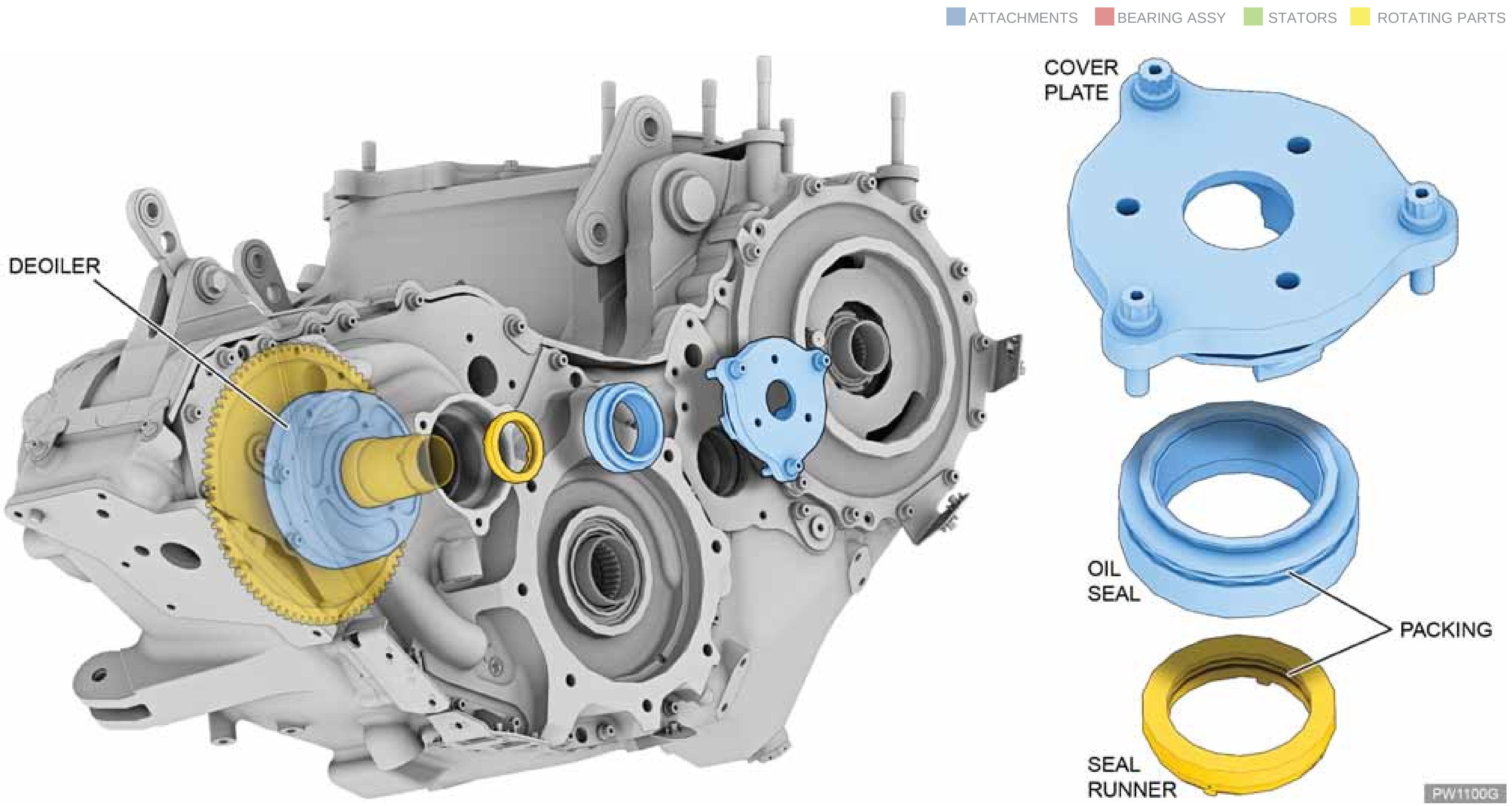
CAUTION

HANDLE THE OIL SEAL WITH CARE. DO NOT SCRATCH OR DAMAGE THE CARBON SEALING SURFACE DURING HANDLING OR INSTALLATION. IF YOU SCRATCH OR DAMAGE THE CARBON SEALING SURFACE, THE SEAL ASSEMBLY MUST BE REPLACED.

Operation:

1. The carbon face and the runner sealing surface are highly polished and parallel, creating a tight seal. A wave washer behind the carbon face forces it to seat against the runner, creating a positive seal when the engine is static. During engine operation, the shaft turns the runner that seals against the carbon, creating an effective seal that eliminates oil leakage from the MGB.

2. Oil is sprayed on the runner to reduce its operating temperature.



BREATHER SYSTEM – DEOILER DRIVE OIL SEAL – ATTACHMENT TO MAIN GEARBOX

BREATHER SYSTEM (Cont.)

No. 3 Bearing Breather Vent Tube

Purpose: LRU PMT

The No.3 Bearing breather vent tube sends breather air directly from the bearing compartment to the deoiler in the Main Gearbox.

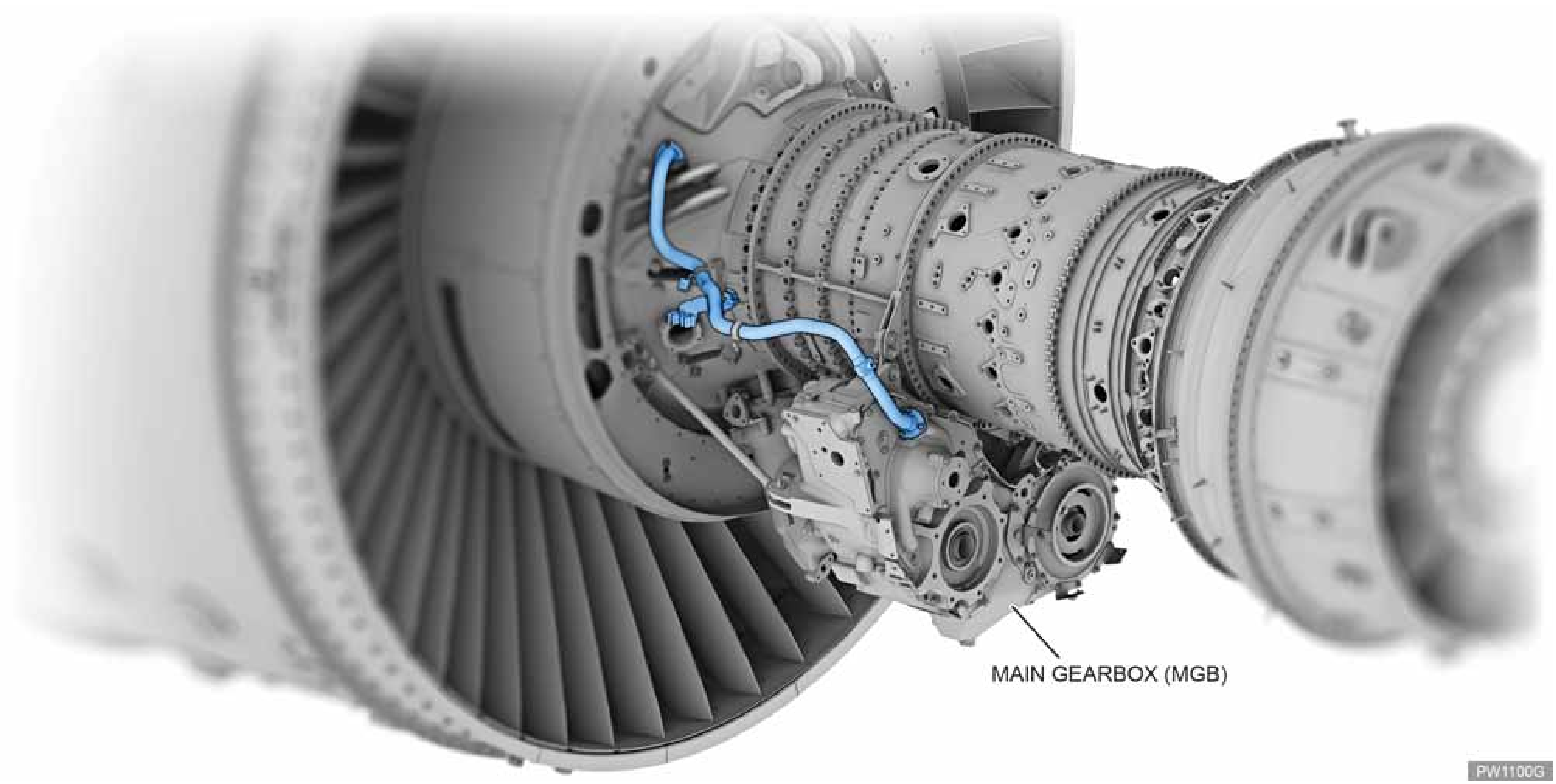
Location:

The vent tube is attached to the CIC at 10:00 and to the rear of the Main Gearbox.

Description:

Air enters the No. 3 Bearing compartment from between the carbon seal and face seal, flowing through the compartment and removing heat. The airflow carries some of the oil that is used in the bearing compartment, lubricating the bearings in the form of a mist.

The No. 3 Bearing vent tube vents this breather air directly to the deoiler in the Main Gearbox.



BREATHER SYSTEM – No. 3 BEARING BREATHER VENT TUBE

BREATHER SYSTEM (Cont.)

Main Oil Tank Deaerator Vent Tube

Purpose: LRU

The main oil tank deaerator vent tube vents excessive tank pressure from the main oil tank.

Location:

The tube is connected to the oil tank deaerator and the Main Gearbox.

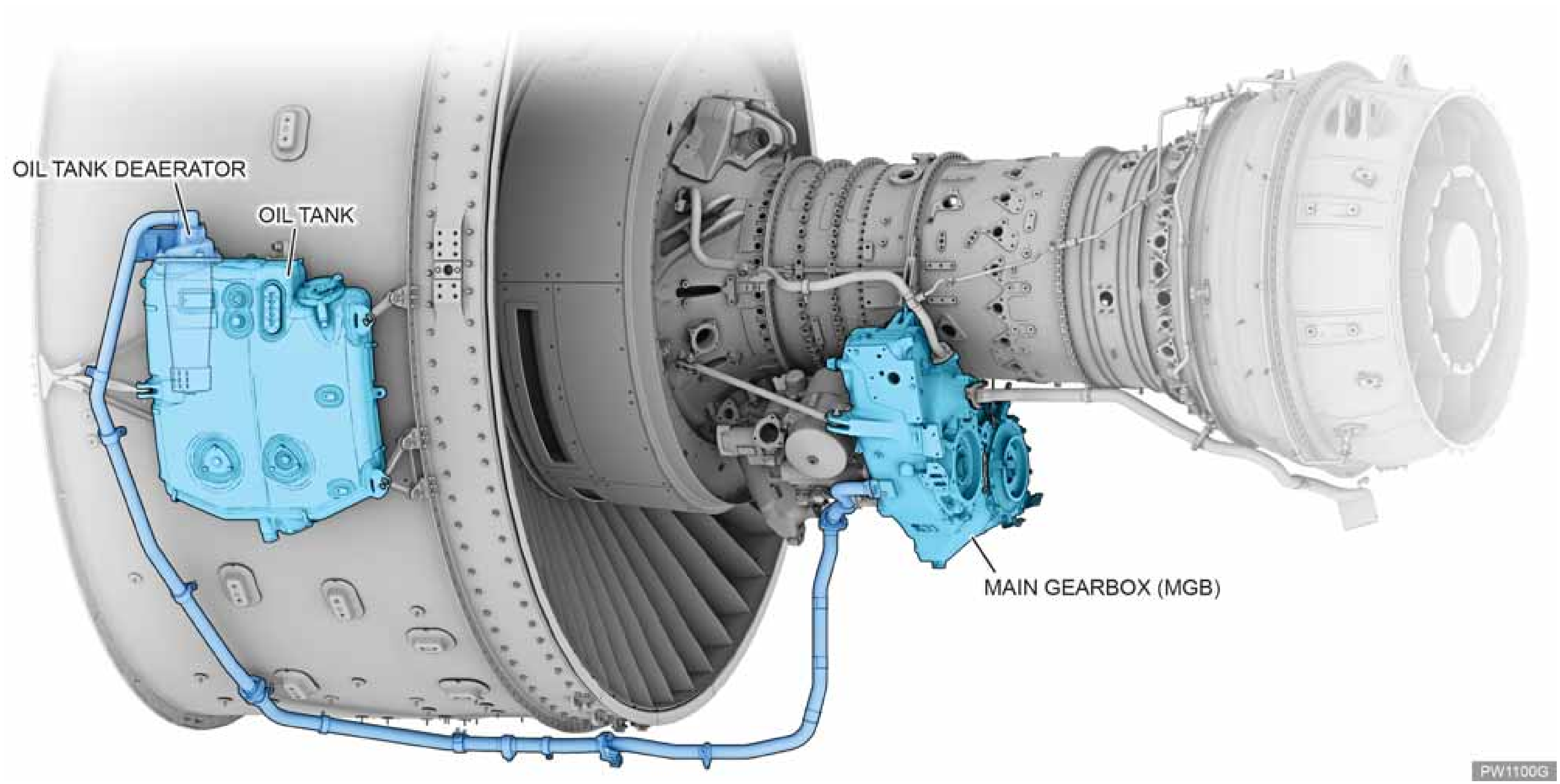
Description:

Sealing air for all bearing compartments mixes with scavenge oil and flows back to the oil tank. A static deaerator in the oil tank separates the oil from the air. The released air pressurizes the oil tank.

Operation:

Pressure in the tank is controlled by a spring-loaded closed, mechanical poppet valve. The valve opens to release excess pressure in the tank and sends the excess air/oil mist to the deoiler that is internal to the Main Gearbox.

Breather air from the Main Gearbox flows internally to the deoiler vent tube.



BREATHER SYSTEM – MAIN OIL TANK DEAERATOR VENT TUBE

BREATHER SYSTEM (Cont.)

Anti-Siphon Tube for Bearing Nos. 5, 6

Purpose: LRU PMT

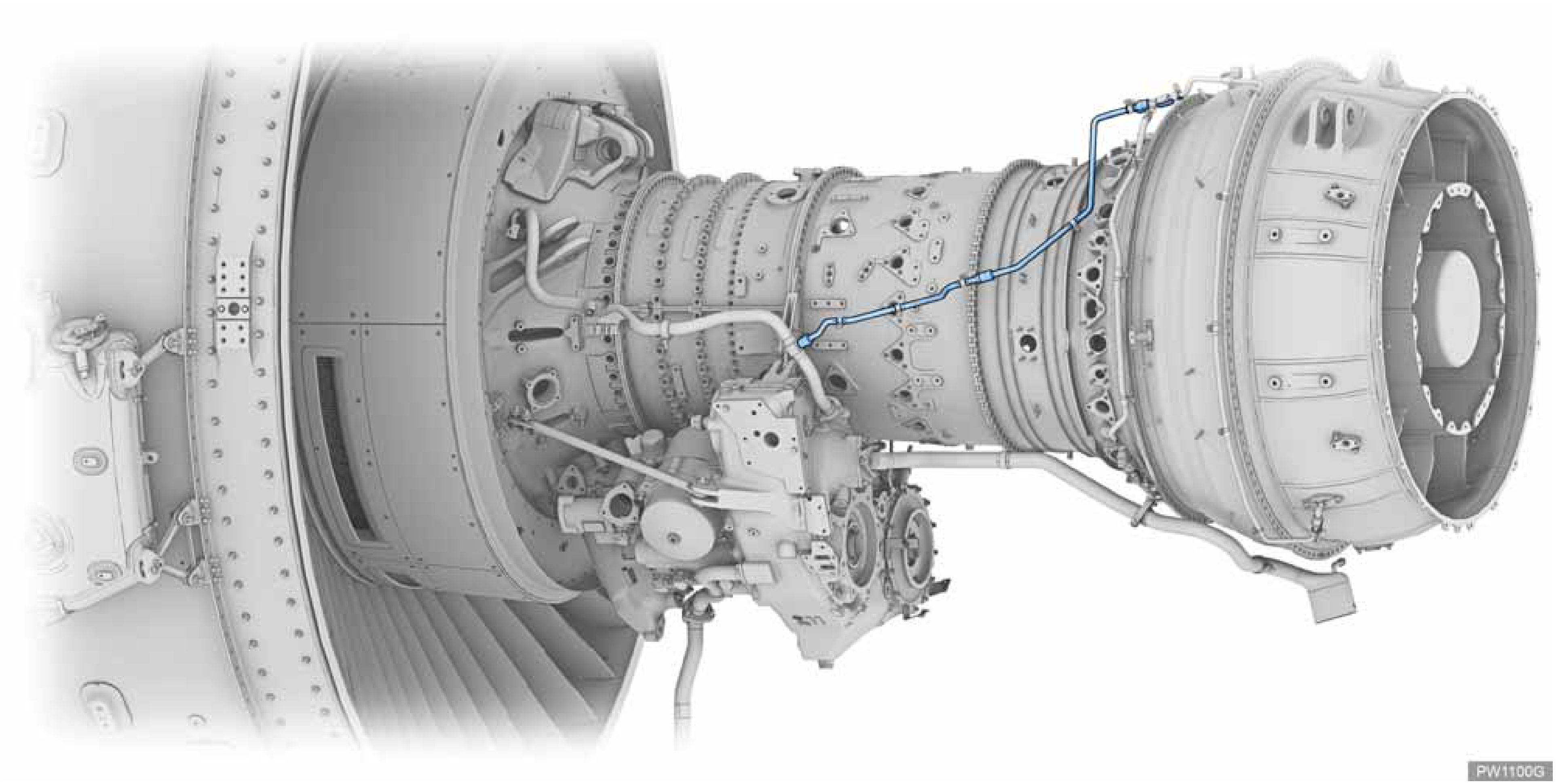
The anti-siphon tube allows some oil to remain in the pressure tube for bearing nos. 5 and 6 after the engine is shut down.

Location:

The anti-siphon tube is on the left side of the engine core. It attaches to the oil pressure “T” fitting for bearing nos. 5 and 6, and to the No. 3 Bearing breather tube.

Description:

Allowing oil to remain in the anti-siphon tube after shutdown prevents coking in the bearing pressure tube.



BREATHER SYSTEM – ANTI-SIPHON TUBE FOR BEARING Nos. 5/6

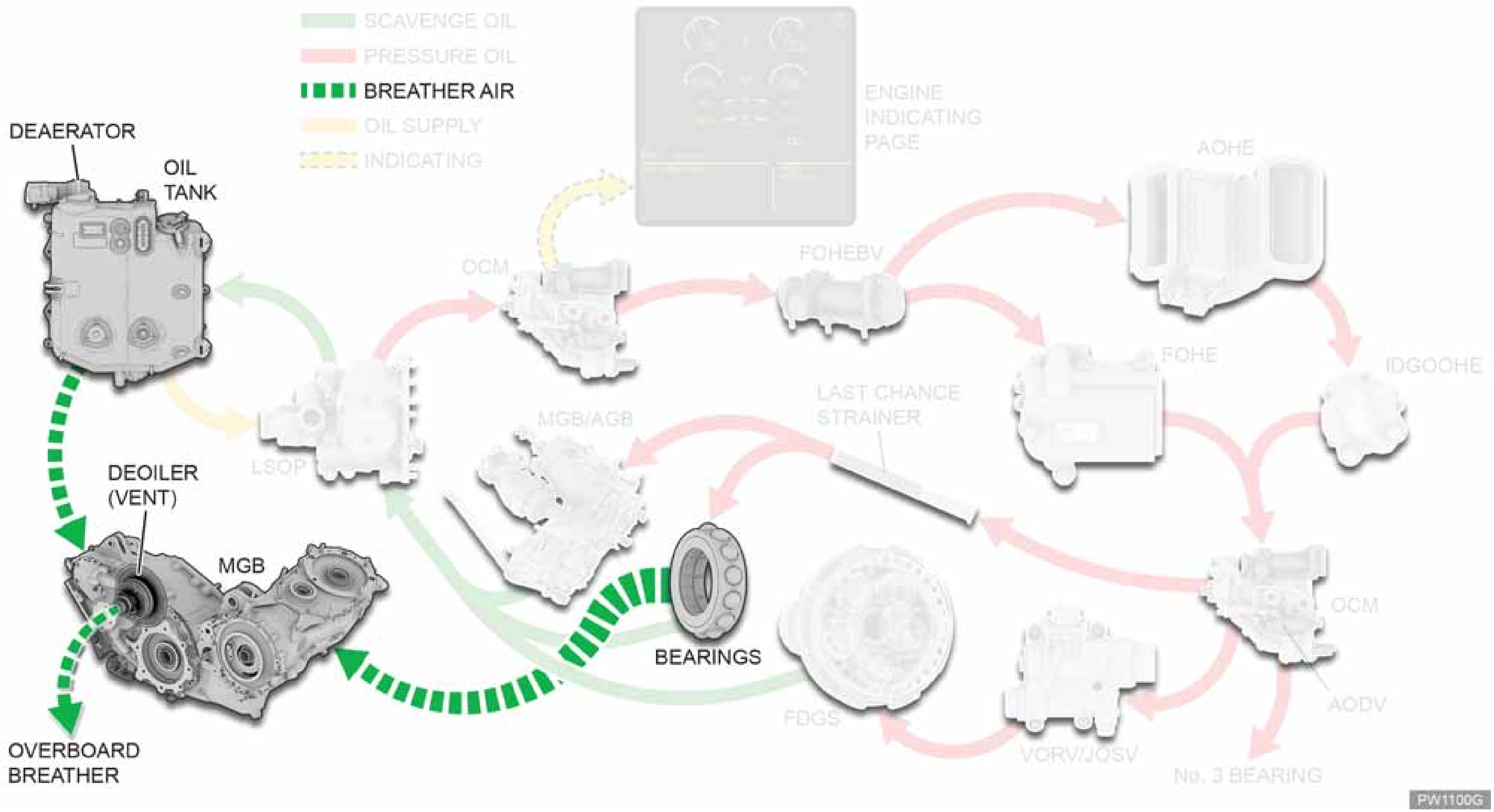
BREATHER SYSTEM (Cont.)

Operation:

1. Combined breather air from the oil tank and from the No. 3 Bearing compartment flows as a mist to the rotating impeller in the deoiler, where oil is separated from the air.

2. The oil drains into the MGB and mixes with the MGB scavenge oil.

3. Breather air from the deoiler goes through the deoiler vent duct and is sent overboard.



BREATHER SYSTEM OIL FLOW

INDICATING SYSTEM

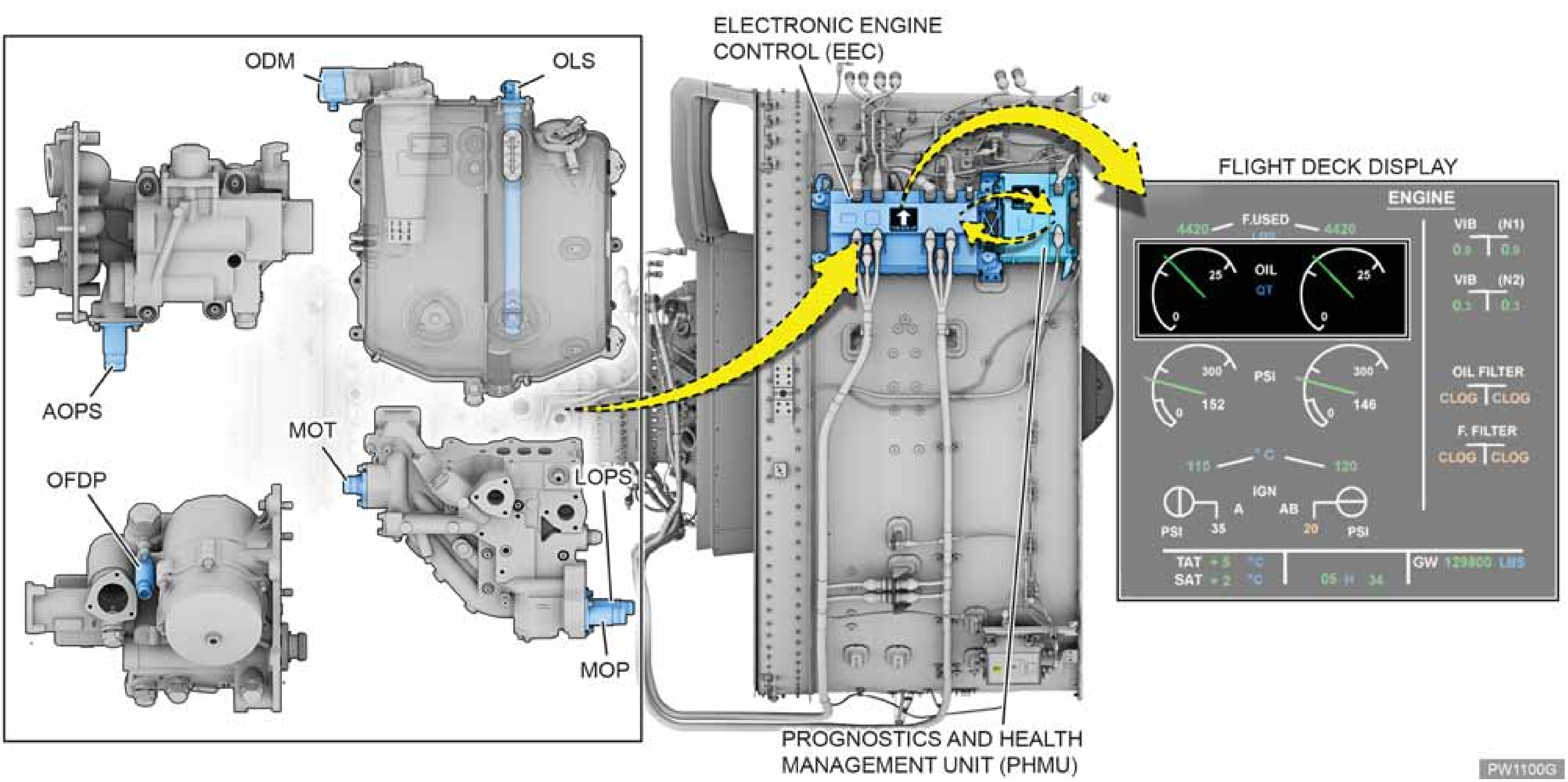
The Indicating System monitors Lubrication System conditions and alerts the flight crew to potential problems.

Components in the system send signals to the Electronic Engine Control (EEC), which in turn notifies the flight deck's Electronic Centralized Aircraft Monitor System (ECAM).

Most of the components are found on the Oil Control Module (OCM) on the left side of the MGB. The Oil Level Sensor (OLS) is mounted internal to the oil tank and the Auxiliary Oil Pressure Sensor (AOPS) is located on the VORV/JOSV manifold.

Sensors are listed below.

- Oil Level Sensor — OLS
- Oil Filter Differential Pressure sensor — OFDP
- Oil Debris Monitor — ODM
- Main Oil Temperature sensor — MOT
- Main Oil Pressure sensor — MOP
- Low Oil Pressure Switch — LOPS
- Auxiliary Oil Pressure Sensor — AOPS



LUBRICATION INDICATING SYSTEM OPERATION

INDICATING SYSTEM (Cont.)

Oil Level Sensor (OLS)

LRU PMT

Purpose:

The Oil Level Sensor indicates the oil level within the oil tank.

Location:

The sensor is internal to the oil tank.

Description:

The OLS is a single-channel transducer with a magnetic float-and-reed switch configuration. A hollow tube is welded to the top mounting plate and has an integral bottom mounting flange that fits into a mating flange inside the bottom of the oil tank assembly. The hollow tube contains a magnetic ball float and a circuit board. The length of the circuit board contains a series of switches.

A single electrical connector is attached to the top mounting plate. The mounting plate is secured to the top of the oil tank assembly with three bolts. An O-ring beneath the mounting plate prevents leakage.

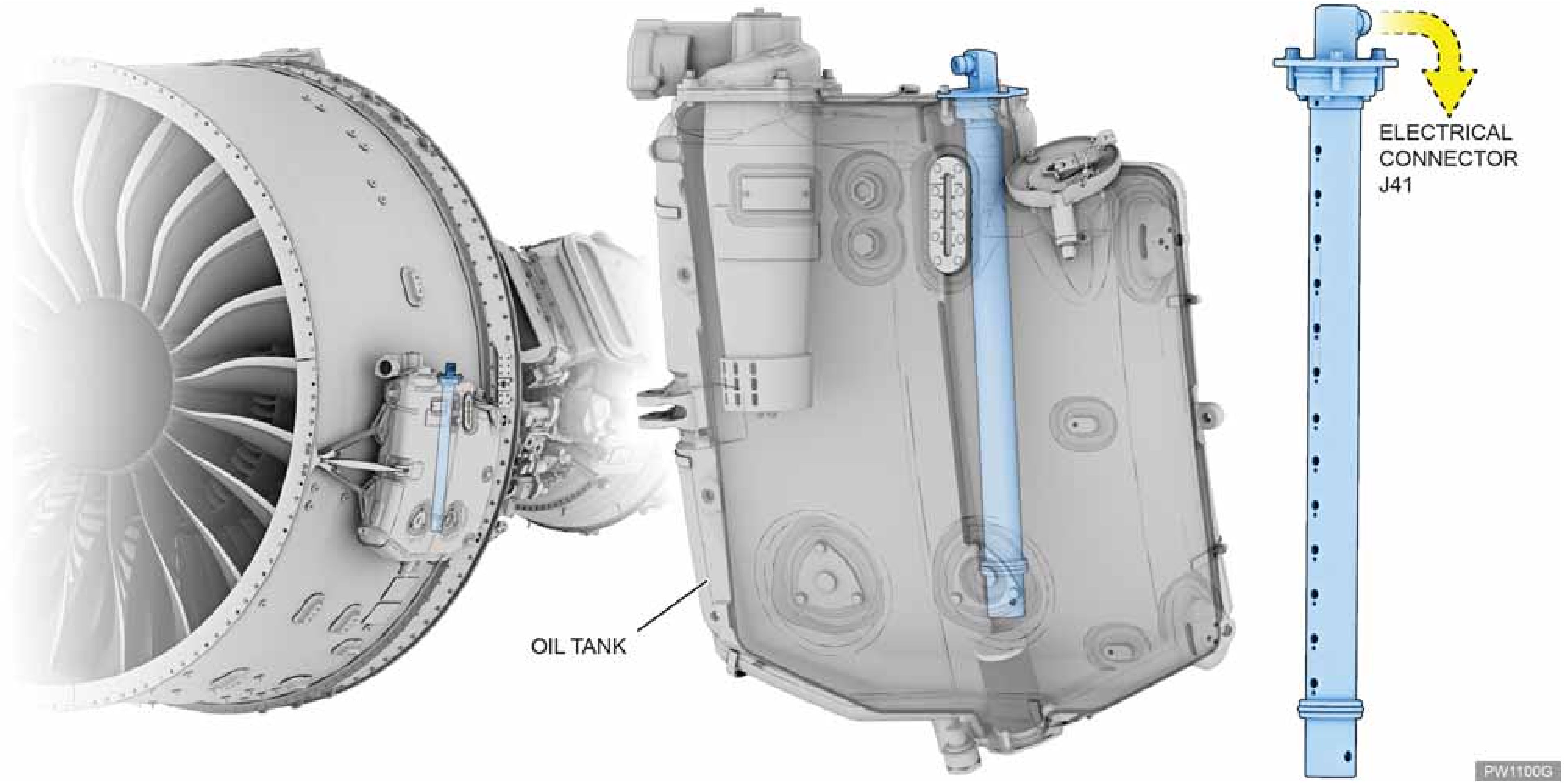
Safety Conditions

WARNING

DO NOT OPEN THE OIL TANK CAP UNTIL 5 MINUTES MINIMUM AFTER ENGINE SHUTDOWN. THIS WILL LET THE PRESSURE BLEED OFF. IF YOU DO NOT OBEY THIS WARNING, HOT OIL CAN BURN YOUR EYES AND SKIN.

Operation:

The magnetic field produced by the magnetic float closes and opens each switch as it passes them while floating on the oil surface. The sensor then outputs a single channel signal to the EEC using a DC voltage that correlates to the oil level in the tank.



INDICATING SYSTEM – OIL LEVEL SENSOR

INDICATING SYSTEM (Cont.)

Oil Filter Differential Pressure (OFDP) Sensor

Purpose: LRU

The Oil Filter Differential Pressure sensor measures the difference in oil pressure upstream and downstream of the oil filter.

Location:

The OFDP sensor is secured to the Lubrication and Scavenge Oil Pump.

Description:

Two bolts secure the OFDP to the LSOP. Two O-rings are installed beneath the mounting flange to prevent oil leakage. If the OFDP sensor is removed on-wing or during a shop visit, the O-rings must be replaced.

The dual-channel sensor consists of an electrical connector and two independent, electrically isolated sensing elements contained within a sealed stainless steel body that protects the sensing elements from damage. Each sensing element consists of a diaphragm with strain gages bonded to the surface and is connected to the electrical connector.

Safety Conditions

CAUTION

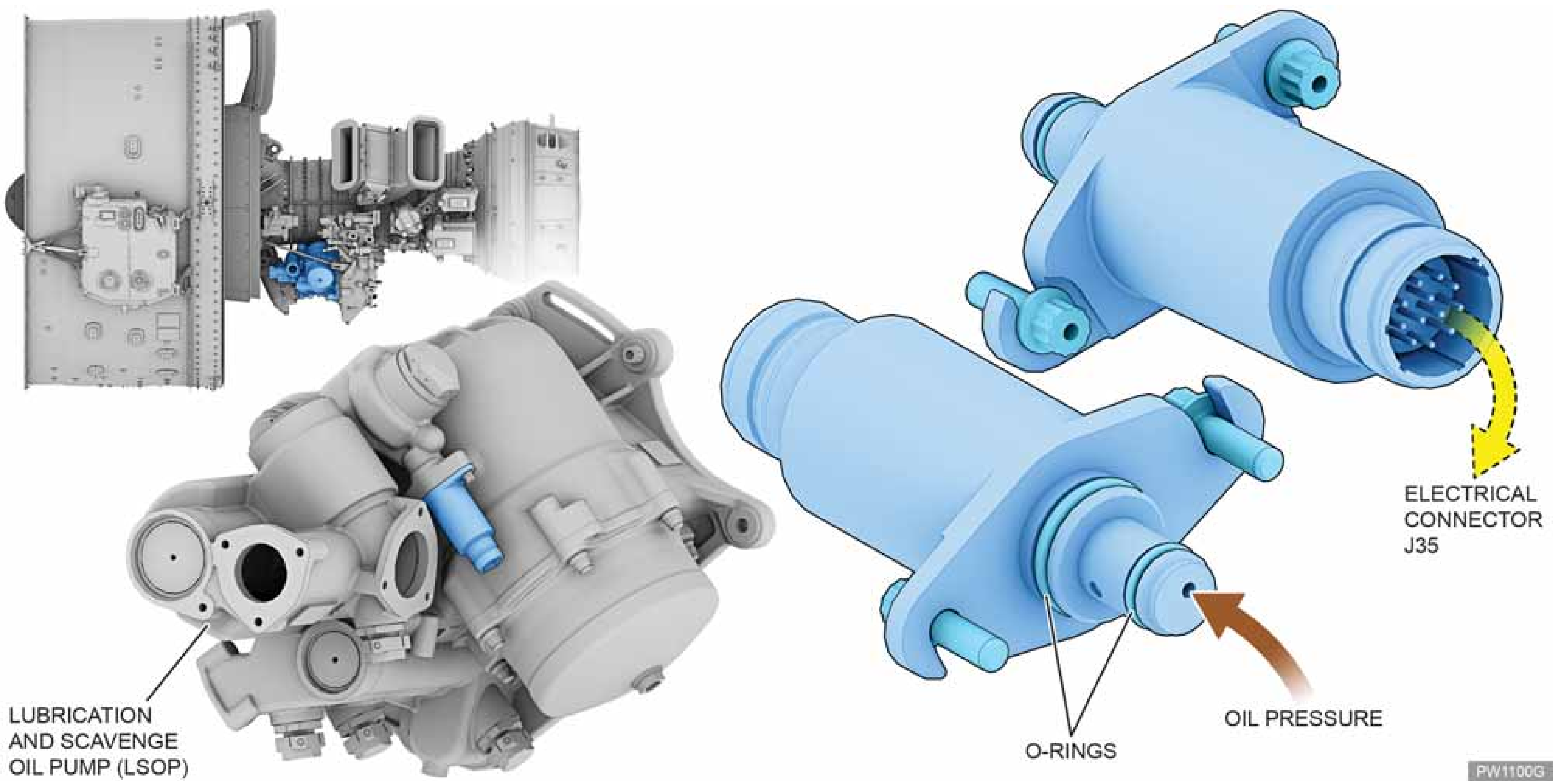
WHEN YOU LOOSEN OR TIGHTEN THE CONNECTOR THERE IS LIMITED CLEARANCE BETWEEN PARTS. IF YOU DO NOT OBEY THIS CAUTION, DAMAGE TO THE ENGINE CAN OCCUR.

Operation:

When pressure is applied, the strain gages change resistance, altering the output voltage. This output voltage for each sensing element correlates directly to oil differential pressure and is sent to the Electronic Engine Control (EEC).

Oil Filter Display Messages

- If the OIL LO PR warning appears, oil pressure has dropped to an advisory (amber warning) or critical (red warning) level.
- If the OIL FILTER CLOG warning appears, follow the MMEL requirements for dispatch with replacing the oil filter.
- If the OIL FILTER DEGRAD warning appears, oil is still flowing through the primary portion of the oil filter. The aircraft may dispatch (GO IF) per MMEL requirements.
- If the OIL FILTER IMPENDING BYPASS SMR warning appears on the ECAM Maintenance Page, the oil filter must be checked at the next maintenance interval.



INDICATING SYSTEM – OIL FILTER DIFFERENTIAL PRESSURE (OFDP) SENSOR

INDICATING SYSTEM (Cont.)

Oil Debris Monitor (ODM)

Purpose: LRU PMT

The Oil Debris Monitor (ODM) detects and measures both ferrous and non-ferrous debris in the Lubrication System.

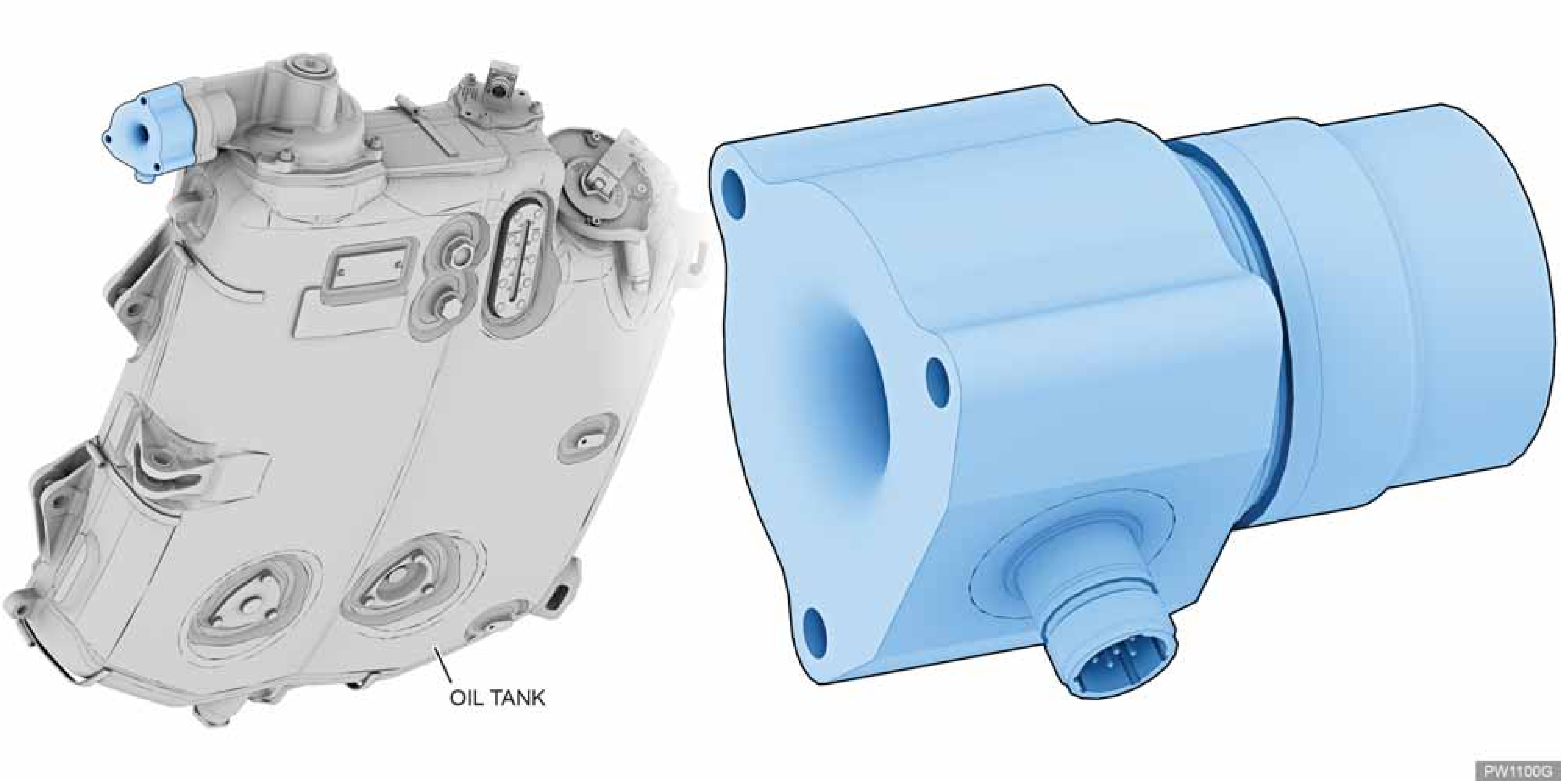
Location:

The ODM is installed between the main oil scavenge line and the deaerator in the oil tank assembly.

Description:

The ODM is a single-channel, in-line sensor that is non-repairable. It consists of a sensing element, a stainless steel body that shields the sensing element from damage, a mounting flange, and an electrical connector. O-rings prevent oil from entering the unit.

The ODM is secured by three bolts which also secure the oil scavenge line to the deaerator. An O-ring provides oil sealing at the deaerator interface and a face seal provides oil sealing at the oil scavenge line interface. Both the O-ring and face seal must be replaced if the ODM is removed on-wing or during a shop visit.



INDICATING SYSTEM – OIL DEBRIS MONITOR (ODM) (1 OF 2)

INDICATING SYSTEM

Oil Debris Monitor (ODM) (Cont.)

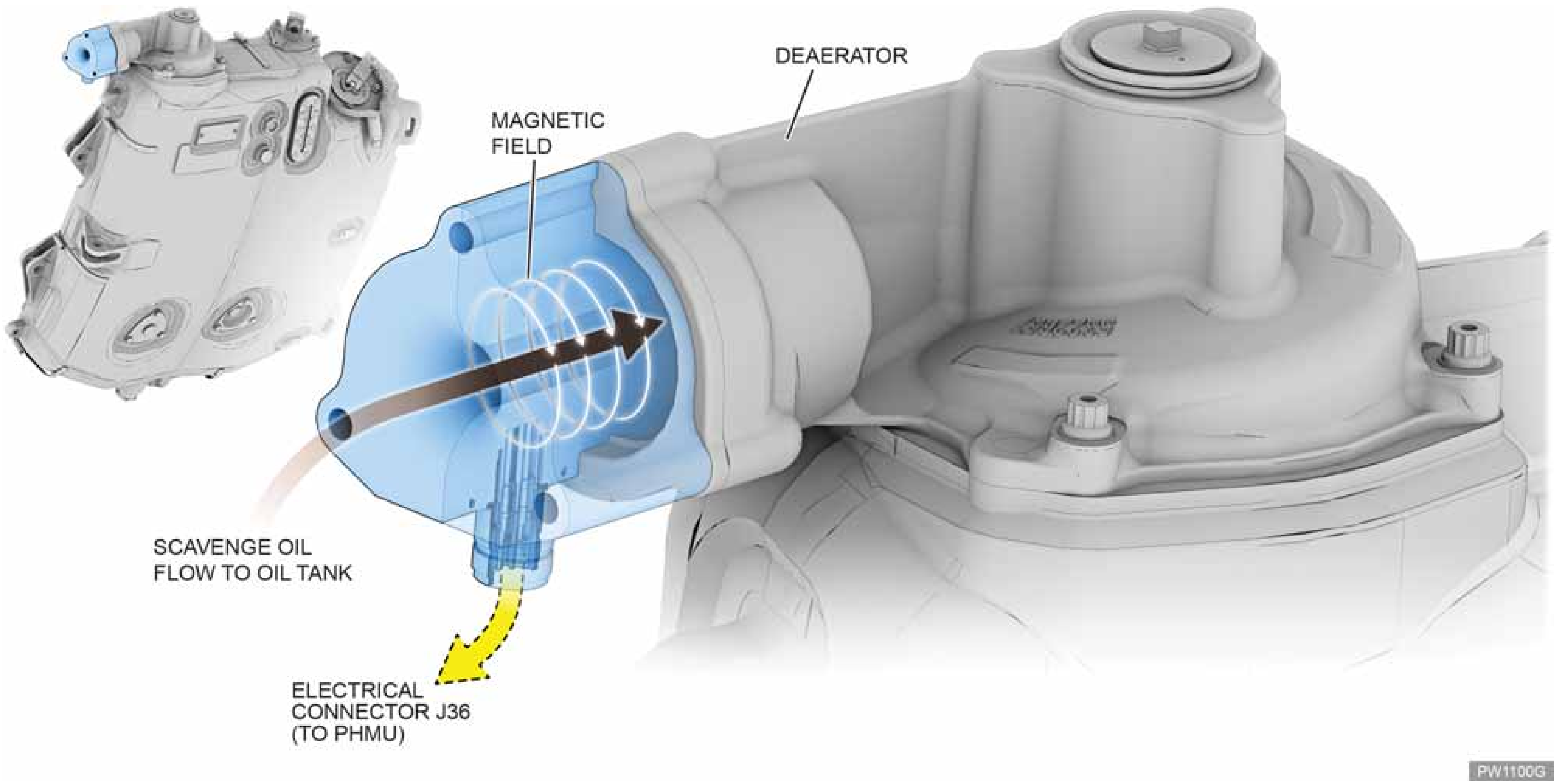
Operation:

The ODM creates an electromagnetic field through which scavenge oil flows. When metallic particles are present in the scavenge oil, the sensing element produces a characteristic signal.

The amplitude of the signal is proportional to the particle size. Its phase allows the signal processing electronics of the Prognostics and Health Management Unit (PHMU) to differentiate between a ferrous and non-ferrous particle.

Ferrous material passing through the electromagnetic field strengthens the field, and non-ferrous material passing through weakens the field. This effect creates two unique signatures used by the PHMU to differentiate the types of particles.

The PHMU processes the signal from the ODM and issues a chip generation rate (the number of chips counted in a given period of time). The chip generation rate signal is then sent to the EEC, where the rate is compared to predetermined values and the appropriate maintenance message or flight deck signal is sent to the EIU.



INDICATING SYSTEM – OIL DEBRIS MONITOR (ODM) (2 OF 2)

INDICATING SYSTEM (Cont.)

Main Oil Temperature (MOT) Sensor

LRU

Purpose:

The Main Oil Temperature (MOT) sensor measures the temperature of scavenge oil returned to the tank.

Location:

The sensor is installed on the OCM.

Description:

The dual-channel sensor consists of two independent, electrically isolated sensing elements; a stainless steel body with mounting flange and a protective tube that shields the sensing elements from damage; and one electrical connector. Components are assembled as a hermitically sealed unit that is non-repairable.

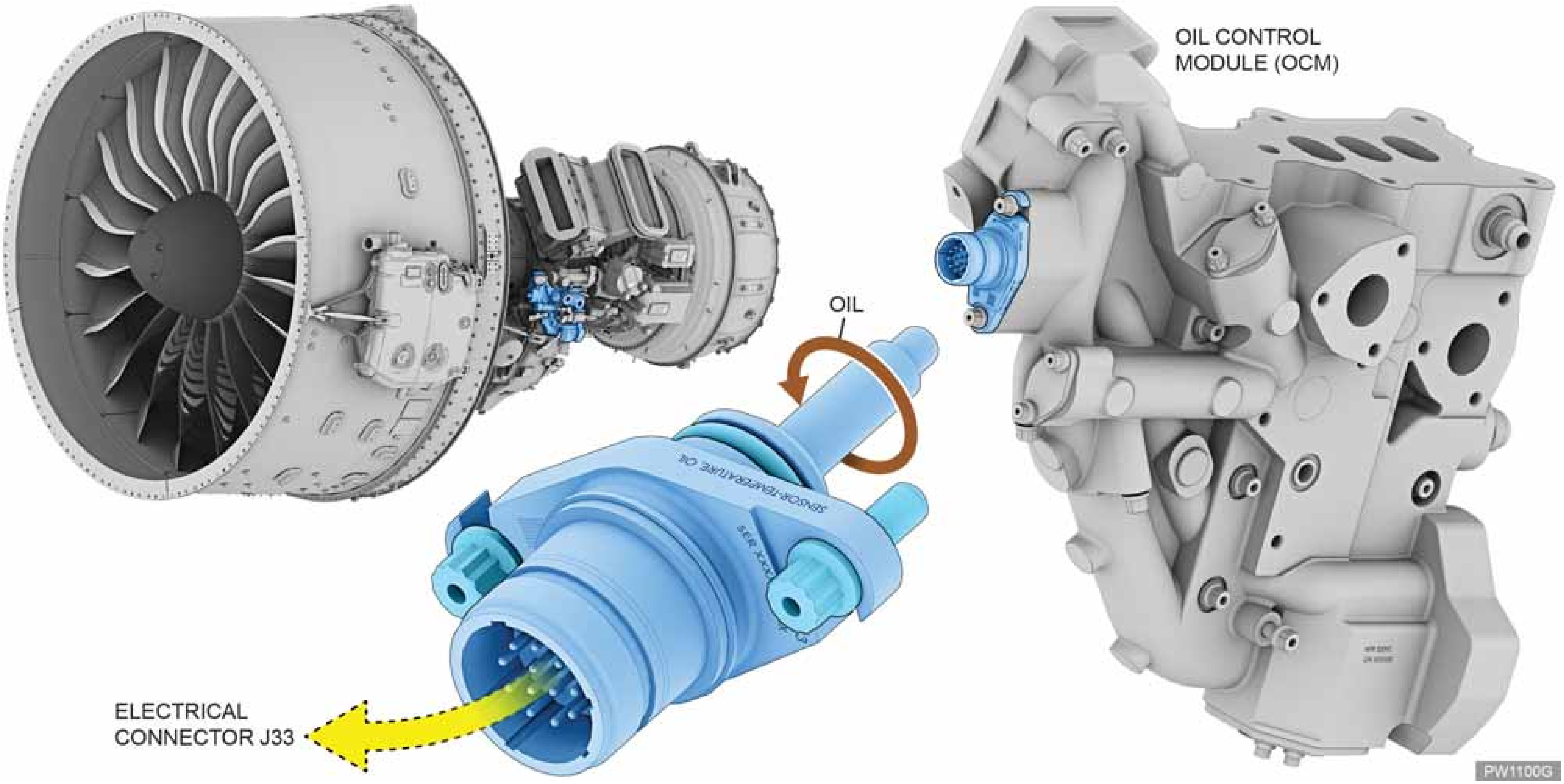
Oil temperature is measured by two independent Resistance Temperature Detector (RTD) sensing elements.

The MOT sensor is secured to the OCM with two bolts. An O-ring is installed beneath the mounting flange to prevent oil leakage.

The O-ring must be replaced if the MOT sensor is removed on-wing or during a shop visit.

Operation:

As the temperature of the sensing element changes, the electrical resistance alters, causing the voltage across the element to change proportionally. Each sensing element is connected to a single electrical connector and sends the oil temperature signal (voltage) to the EEC over separate channels A and B. Both channels share the same electrical connector.



INDICATING SYSTEM – MAIN OIL TEMPERATURE (MOT) SENSOR

INDICATING SYSTEM (Cont.)

Main Oil Pressure (MOP) Sensor

Purpose:

LRU

The Main Oil Pressure sensor measures oil pressure on the supply side of the Lubrication System.

Location:

The sensor is installed on the Oil Control Module.

Description:

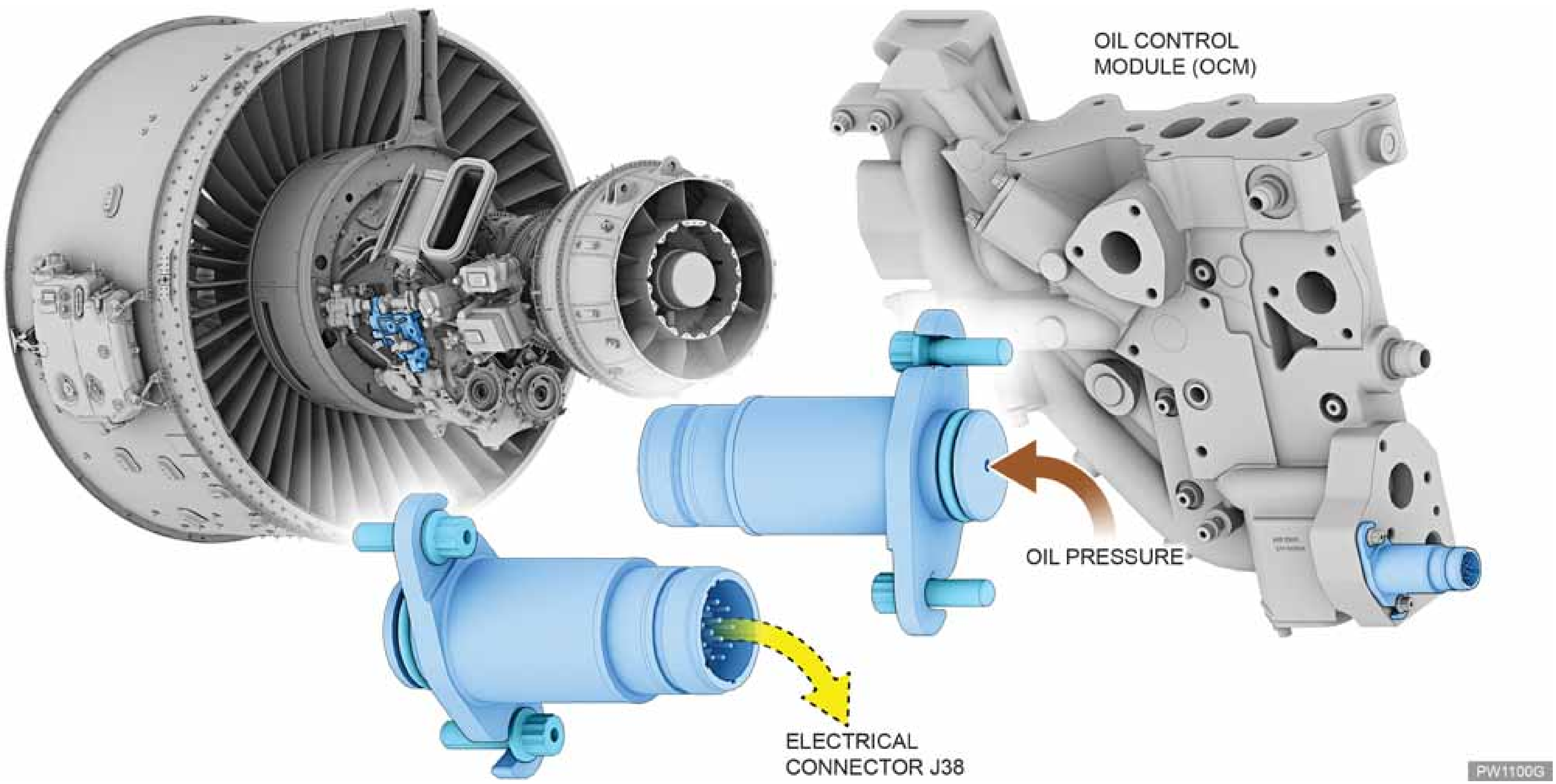
The dual-channel sensor consists of two independent, electrically isolated sensing elements; a stainless steel body with a mounting flange, and which shields the sensing elements from damage; and one electrical connector.

Each sensing element consists of a diaphragm with strain gages bonded to the surface.

The MOP sensor is secured to the Oil Control Module (OCM) with two bolts. An O-ring is installed beneath the mounting flange to prevent oil leakage. The O-ring must be replaced if the MOP sensor is removed on-wing or during a shop visit.

Operation:

When pressure is applied, the strain gages change resistance, altering the output voltage. This output voltage correlates directly to oil pressure. Each sensing element is connected to a single electrical connector and sends the oil pressure signal to the Electronic Engine Control (EEC) over separate channels A and B. Both channels share the same electrical connector.



INDICATING SYSTEM – MAIN OIL PRESSURE (MOP) SENSOR

INDICATING SYSTEM (Cont.)

Low Oil Pressure Switch (LOPS)

Purpose: LRU

The Low Oil Pressure Switch sends a low oil pressure signal directly to the Engine Interface Unit (EIU) when oil pressure has been reduced to a level below which engine operation is not recommended.

Location:

The LOPS is mounted to the bottom of the OCM on the supply side of the Lubrication System downstream of the MOP sensor.

Description:

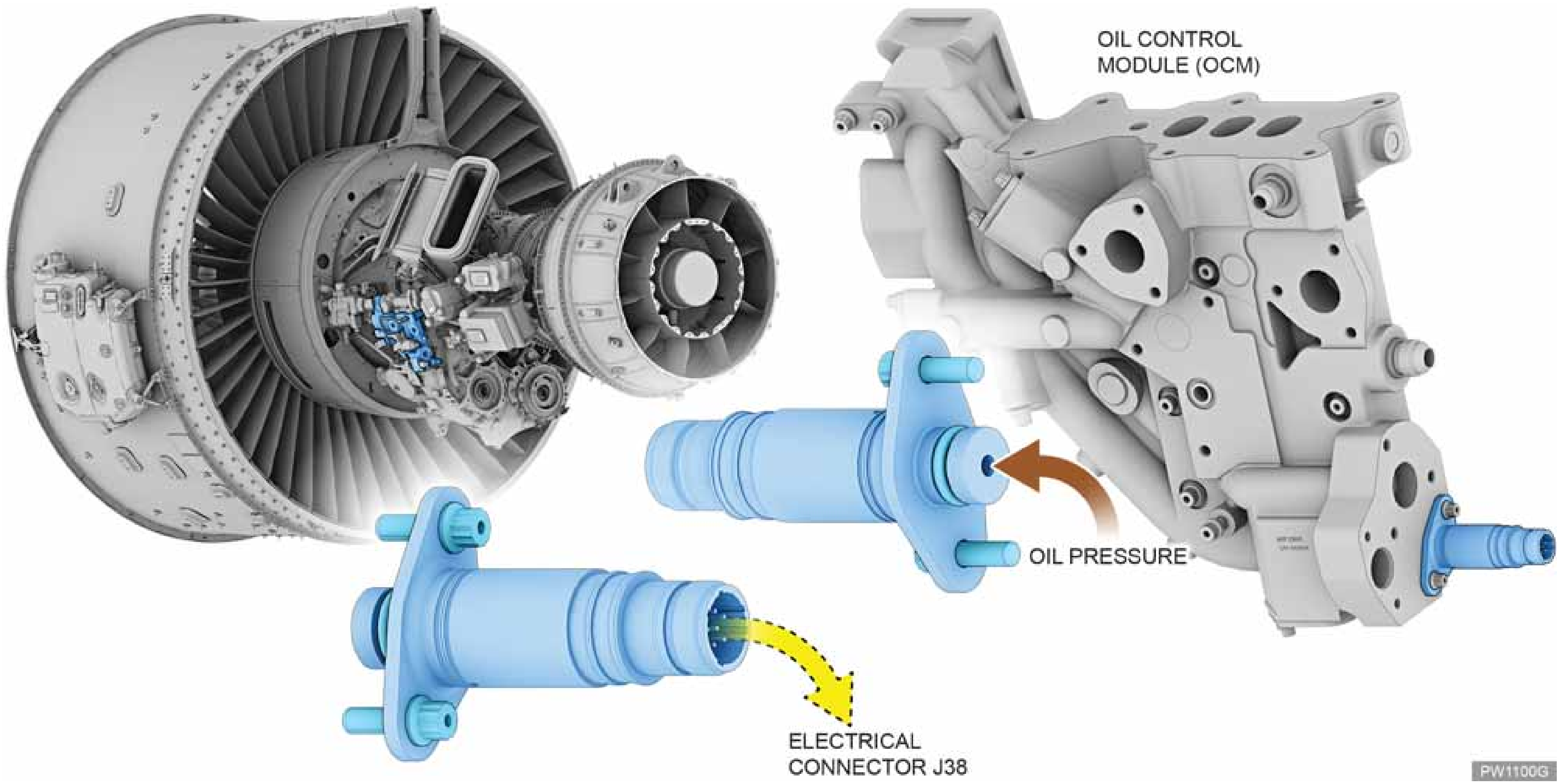
The LOPS consists of a diaphragm sensing element, a spring, a mechanical switch, a stainless steel body, and one electrical connector. The stainless steel body, chosen for its strength and resistance to corrosion, has a mounting flange and shields the internal components from damage.

An O-ring is installed beneath the mounting flange to prevent oil leakage. The O-ring must be replaced if the LOPS is removed on-wing or during a shop visit.

Operation:

The mechanical switch is always in the closed (actuated) position during engine operation and when oil pressure is applied to the diaphragm sensing element. However, when the engine is operating and the applied oil pressure decreases below a predetermined design value, the spring force on the diaphragm is greater than the applied oil pressure on the diaphragm-sensing element. This allows the spring to displace the diaphragm and open the mechanical switch to the deactuated position.

The low oil pressure electrical signal is then sent to the EIU, bypassing the EEC.



INDICATING SYSTEM – LOW OIL PRESSURE SWITCH (LOPS)

INDICATING SYSTEM (Cont.)

Auxiliary Oil Pressure Sensor (AOPS)

Purpose:

LRU

The Auxiliary Oil Pressure Sensor detects latent failures in the Journal Oil Shuttle Valve or the windmill/auxiliary pump.

Location:

The AOPS is secured to the manifold for the Variable Oil Reduction Valve and the Journal Oil Shuttle Valve.

Description:

The dual-channel sensor measures the pressure of the oil being delivered to the journal bearings in the fan drive gearbox under normal, windmill, and negative-G conditions. The measurement detects latent failures in the JOSV or the windmill/auxiliary pump.

The sensor consists of two independent, electrically isolated sensing elements, one electrical connector, and a stainless steel body with a mounting flange, which shields the sensing elements from damage.

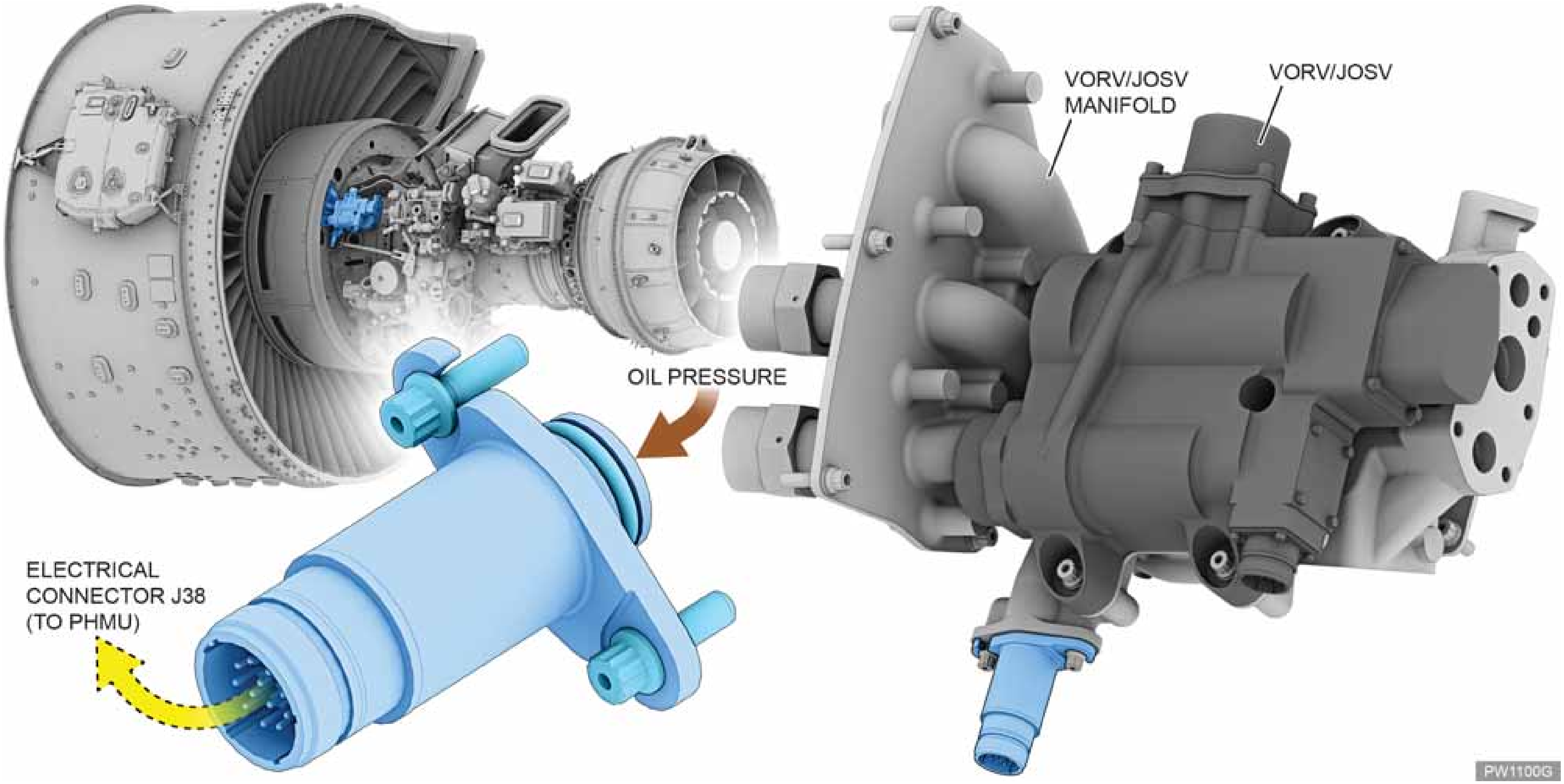
The sensor is secured with two bolts to the VORV/JOSV manifold. The O-ring must be replaced if the sensor is removed on-wing or during a shop visit.

Operation:

Each sensing element consists of a diaphragm with strain gages bonded to the surface.

When pressure is applied, the strain gages change resistance, altering the output voltage. This output voltage correlates directly to oil pressure.

Each sensing element is connected to a single electrical connector and sends the oil pressure signal to the PHMU over separate channels A and B. Both channels share the same electrical connector.



INDICATING SYSTEM – AUXILIARY OIL PRESSURE SENSOR (AOPS)

INDICATING SYSTEM (Cont.)

Flight Deck Display

The flight deck ECAM Secondary Engine Parameters page displays Lubrication System conditions for both engines, using three separate display pages depending on the type of information: Engine Indicating, Engine Status, and Maintenance Mode (Interactive Mode). The chart gives details about the display for each page.

Page	Display Type	Display Condition
Secondary Engine Parameters	• Oil pressure, temperature, quantity	Engine is in operation
Engine Status	• Details about the cause of the ECAM message	Selected by crew
Multipurpose Control and Display Unit (MCDU)	• Faults for oil pressure, pressure, temperature, quantity	Only displays in “interactive” mode

Oil pressure displayed on the Secondary Engine Parameters page is measured in pounds per square inch (PSI) and temperature in degrees Celsius (°C). These parameters will change color on the display if they start to go outside of the normal range.

- Green — Normal range
- Green pulsing — If pressure exceeds OIL HIGH PRESSURE ADVISORY
- Amber — Approaching red line limit that signals low oil temperature
- Red — Red line limit

Oil quantity displayed on the Secondary Engine Parameters page is measured in quarts (QTS). The display changes color depending on condition.

- Green — Normal range
- Green pulsing — If quantity drops below advisory level
- Amber — Quantity below limit
- Red — Red line limit

SECONDARY ENGINE PARAMETERS PAGE, LOWER DISPLAY

Image courtesy of IAE

PW1100G

INDICATING SYSTEM – FLIGHT DECK OIL PARAMETERS

LUBRICATION SYSTEM SERVICING

Oil Tank Procedure

Servicing is not required prior to departure if the engine was serviced on arrival, and pre-departure walk-around checks confirm there are no oil pools or drips from the drain mast or overboard breather.

Servicing the Engine With Oil: 5 to 60 Minutes After Shutdown

Where conditions permit, the oil tank should be checked and oil should be added if necessary, within a period of 5 minutes to 60 minutes after engine shutdown. The oil sight glass is most accurate during this time interval.

- If the oil level in the sight glass is at or above the *−1* mark, DO NOT add oil.
- If the oil level in the sight glass is below the *−1* mark, add engine oil into the filler neck until no more oil can be added without overflow into the scupper drain.

NOTE

Oil level may be above the sight glass level due to thermal expansion. No action is required for this condition under 60 minutes after engine shutdown.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AND THE ADJACENT COMPONENTS AFTER ENGINE SHUTDOWN. THE ENGINE, THE ENGINE OIL AND THE ADJACENT COMPONENTS CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS INSTRUCTION, INJURY CAN OCCUR.

BE CAREFUL WHEN YOU USE CONSUMABLE MATERIALS. OBEY THE MATERIAL MANUFACTURER'S INSTRUCTIONS AND YOUR LOCAL REGULATIONS.

WAIT FIVE MINUTES MINIMUM TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE YOU DO THIS PROCEDURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

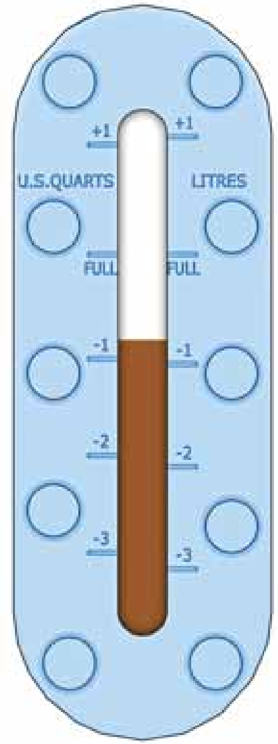
DO NOT MOTOR THE ENGINE BEFORE CHECKING THE OIL LEVEL DURING THE 5 TO 60 MINUTES AFTER ENGINE SHUTDOWN TIME INTERVAL.

WIPE CLEAN ALL PARTS AND TOOLS AS NECESSARY TO REMOVE UNWANTED DEBRIS AND PREVENT DAMAGE TO THE ENGINE.

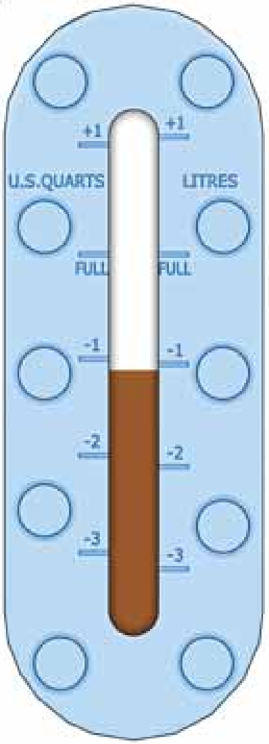
- The stable oil level in the sight glass will now be in the FULL mark range.
- If only a small amount of oil was added prior to oil overflow into the scupper drain, check to make sure the flapper valve opened.
- If the aircraft is not parked on a level, the oil level indication in the sight glass is affected and may be above the full mark. This is acceptable. The Oil System is serviced correctly if no more oil can be added without overflow into the scupper drain.

IF THE OIL LEVEL IN THE SIGHT GLASS IS **AT** OR **ABOVE** THE -1 MARK:

DO NOT ADD OIL



IF THE OIL LEVEL IN THE SIGHT GLASS IS **BELOW** THE −1 MARK, **ADD ENGINE OIL** INTO THE FILLER NECK UNTIL NO MORE OIL CAN BE ADDED WITHOUT OVERFLOW INTO THE SCUPPER DRAIN



PW1100G

LUBRICATION SYSTEM SERVICING – 5 TO 60 MINUTES AFTER SHUTDOWN

LUBRICATION SYSTEM SERVICING

Oil Tank Procedure (Cont.)

Servicing the Engine With Oil: 1 to 10 Hours After Shutdown

Examining the Oil Level Indication In the Sight Glass

- If the oil level is above *+1*, the engine is over-serviced and the oil tank over-servicing task must be completed.
- If the oil level is at or above the *−3* mark, DO NOT add oil.
- If the oil level is below the *−3* mark, add oil until the level is above the mark, but do not add more than three quarts.
- If the oil level is not above the *−3* mark after adding three quarts of oil, then you must complete a dry motor procedure.

Safety Conditions

WARNING

IF POSSIBLE, KEEP FUEL AND OIL AWAY FROM YOUR SKIN. USE PROTECTIVE CLOTHES. FUEL AND OIL CAN DRY YOUR SKIN AND CAUSE SKIN IRRITATION.

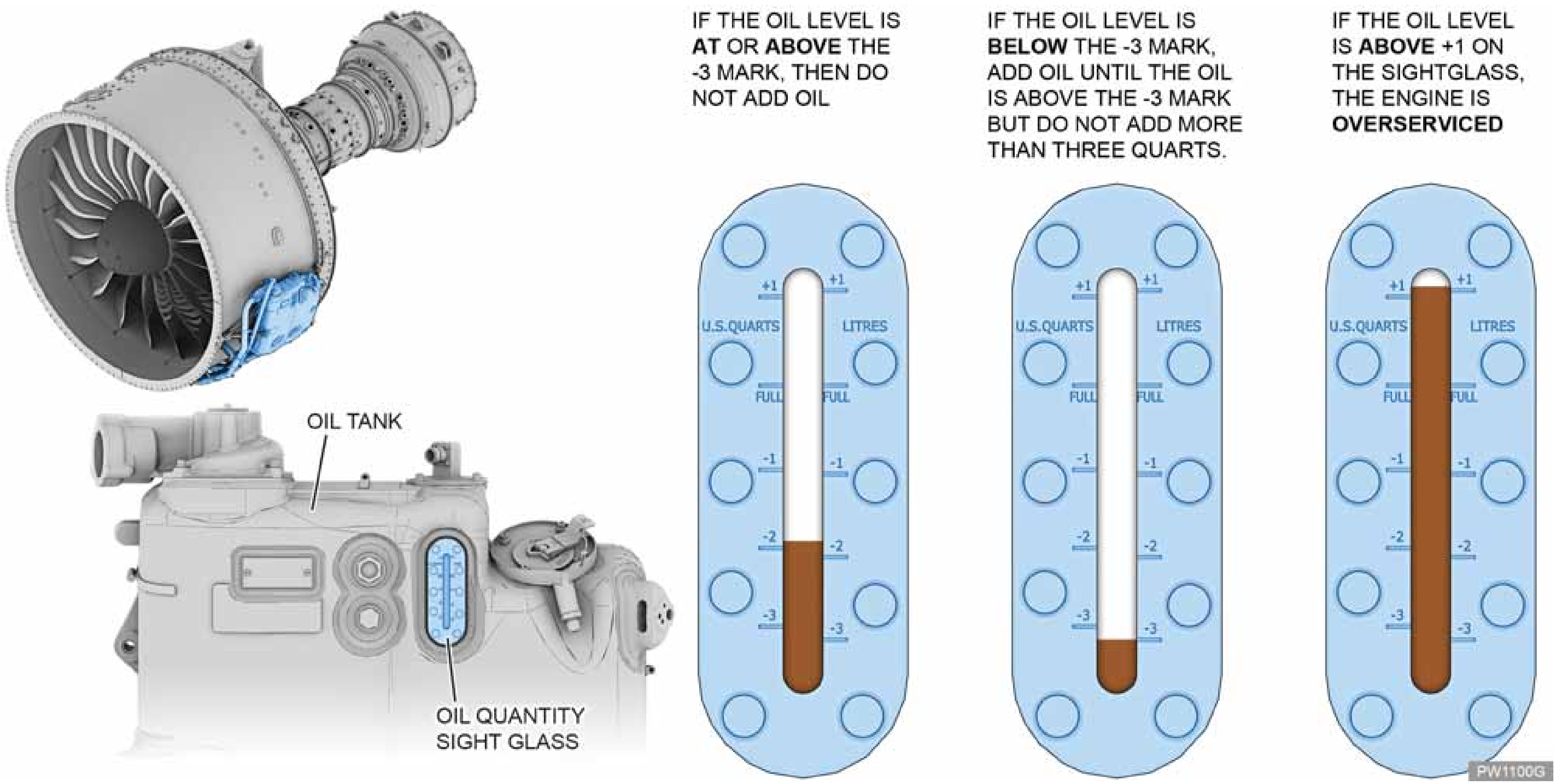
CAUTION

YOU MUST ONLY USE ENGINE OILS SPECIFIED IN SERVICE BULLETIN PW1000G-D-79-00-0002-00A-930A-D. THE MIXING OF DIFFERENT BRANDS OF APPROVED OILS IS NOT RECOMMENDED BUT IS PERMITTED WITHIN THE LIMITS SPECIFIED IN THE SERVICE BULLETIN. THE USE OF UNAPPROVED TYPES OR BRANDS OF OILS IS NOT PERMITTED AND CAN CAUSE DAMAGE TO THE ENGINE.

DO NOT LET FUEL OR OIL FALL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL OR OIL WITH A CLOTH. THE FUEL OR OIL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

DO NOT PUT TOO MUCH OIL IN THE ENGINE OIL SYSTEM. DO NOT OPERATE THE ENGINE WITH TOO MUCH OIL. THIS CAN CAUSE DAMAGE TO THE ENGINE.

DO NOT ADD OIL AFTER MOTORING OR AFTER LOW POWER OPERATION IN EXTREMELY COLD ENVIRONMENTS (-34 °F (-37 °C) OR BELOW). THERE CAN BE UP TO A 3.5 QUART (3.3 LITER) REDUCTION (GULP) IN THE STATIC OIL LEVEL UNDER THESE CONDITIONS. DO THE OIL LEVEL CHECK AFTER THE ENGINE IS OPERATED AT TEMPERATURE AS SPECIFIED IN THE SERVICING TASK. IF YOU DO NOT DO THIS, YOU CAN OVER SERVICE THE ENGINE OIL SYSTEM.



LUBRICATION SYSTEM SERVICING – 1 TO 10 HOURS AFTER SHUTDOWN

LUBRICATION SYSTEM SERVICING

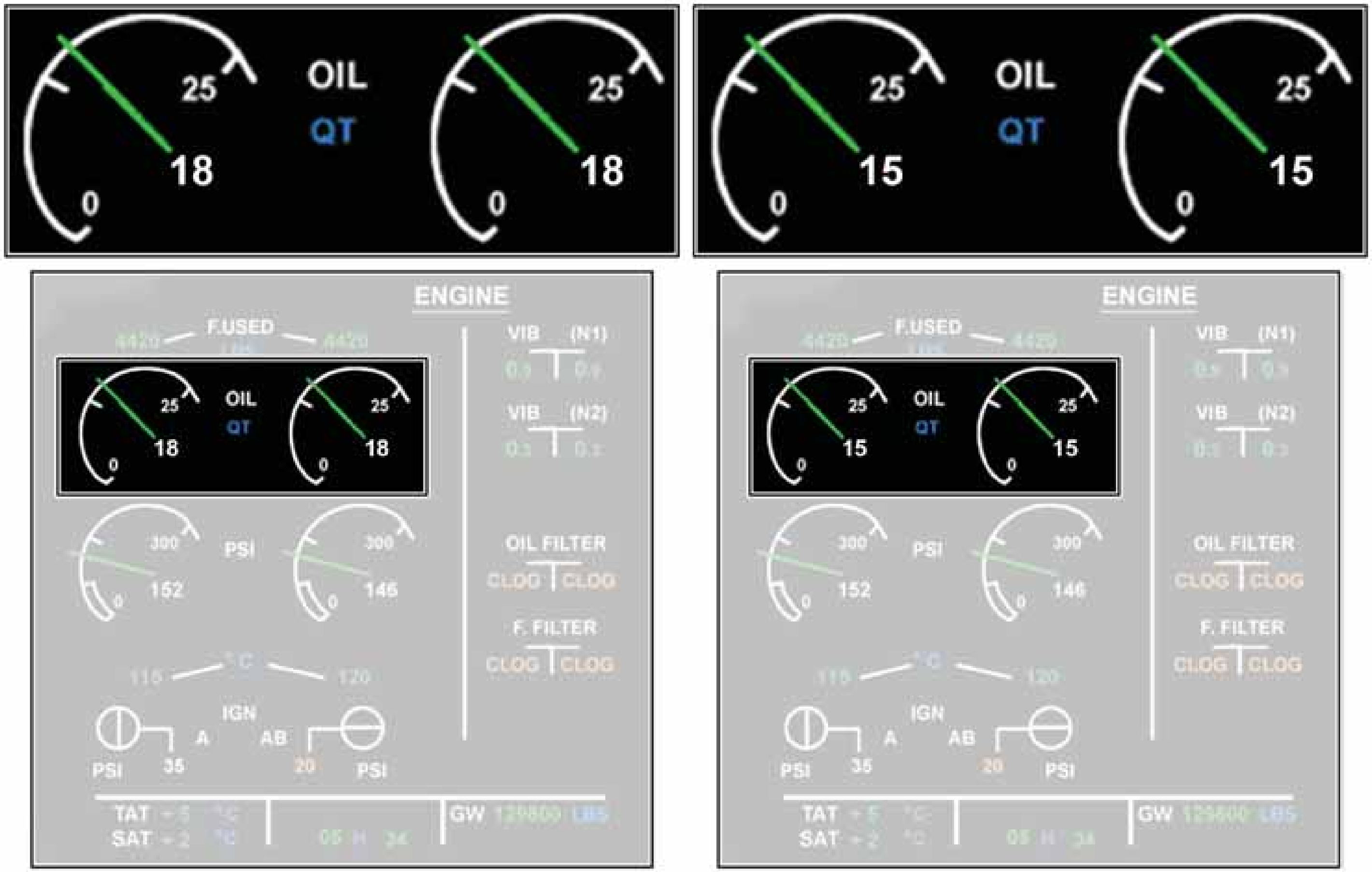
Oil Tank Procedure (Cont.)

Servicing the Engine With Oil: More than 10 Hours After Shutdown

Perform an engine dry motor procedure and examine the oil level using cockpit indication.

- If the oil level is more than 20 quarts, the engine is over-serviced and the engine over-servicing task must be completed.
- If the oil level is between 16 and 20 quarts, an engine idle ground run is required. After engine shutdown, follow the procedure for servicing engine oil within a period of 5 minutes to 60 minutes after engine shutdown.
- If the oil level is less than 16 U.S. quarts (15.1 liters), add oil to the −*3* mark on the sight glass. Record the amount of oil added.

OIL LEVEL IS BETWEEN 16 AND 20 QUARTS. AN IDLE ENGINE RUN IS REQUIRED.



OIL LEVEL IS LESS THAN 16 US QUARTS (15.1 LITERS). ADD OIL TO THE -3 MARK ON THE SIGHTGLASS.

ENGINE WARNING DISPLAYS

PW1100G

LUBRICATION SYSTEM SERVICING – FLIGHT DECK DISPLAY MORE THAN 10 HOURS AFTER SHUTDOWN

LUBRICATION SYSTEM SERVICING (Cont.)

Main Gearbox Drain Plugs

Purpose:

One drain plug allows oil to drain from the Main Gearbox (MGB). Two additional drain plugs allow oil to drain from the Distribution and Scavenge systems.

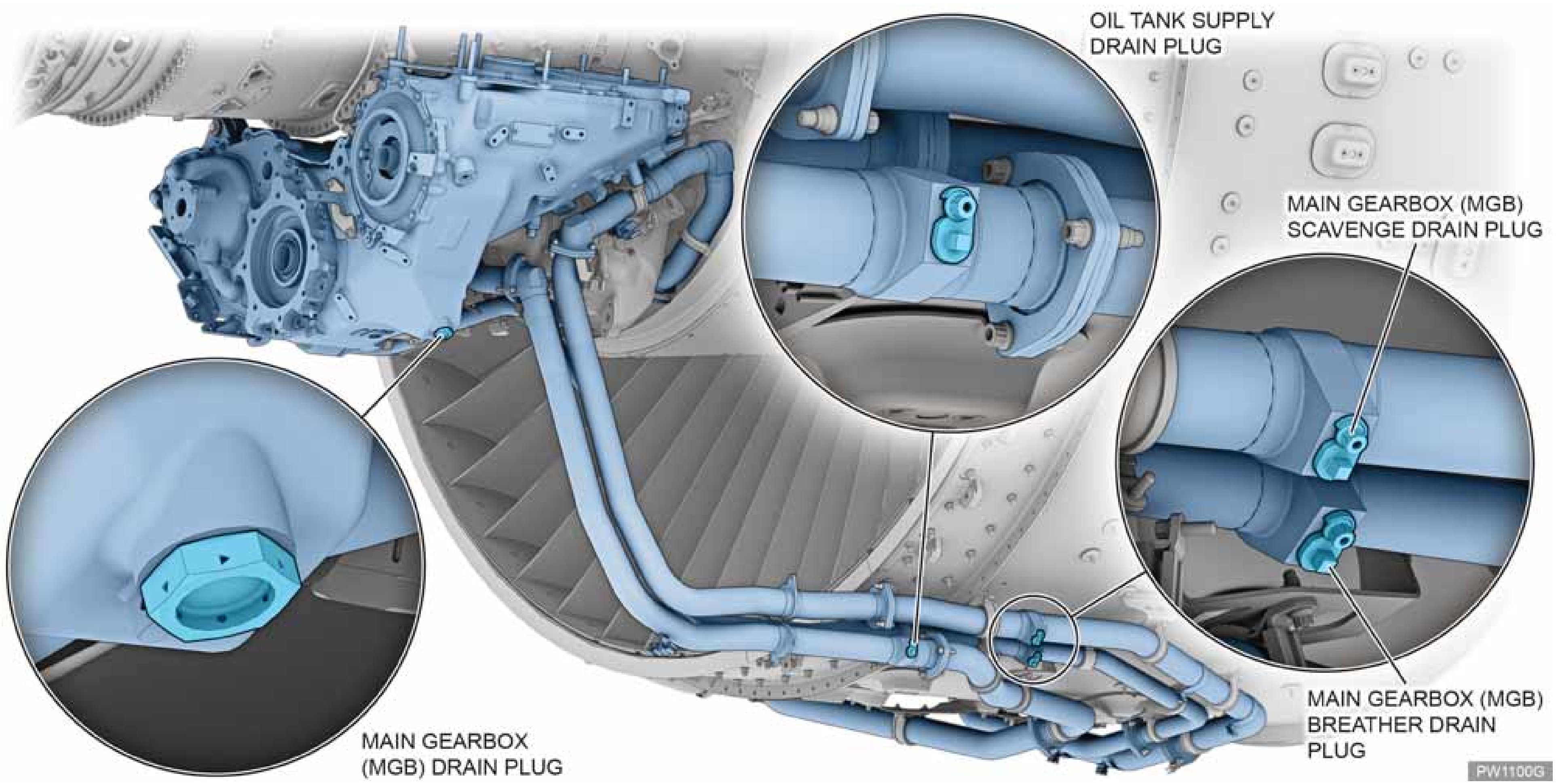
Location:

The drain plugs are located at the bottom of the MGB.

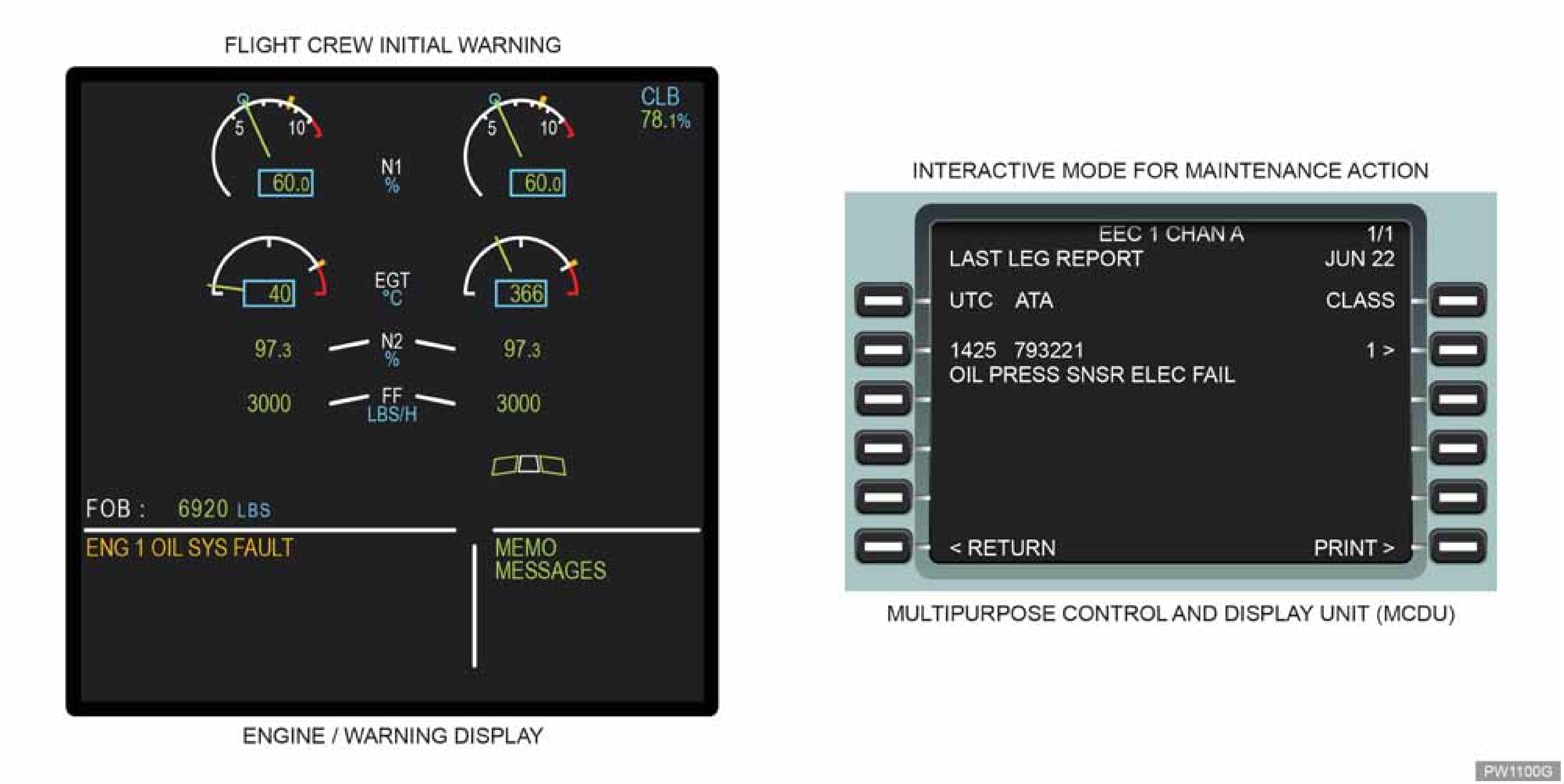
Description:

The drain plugs are installed into the MGB housing, secured by single-bolt flanges.

O-rings are used to seal the drain plugs. After the oil is drained, the O-ring is replaced prior to plug installation.



LUBRICATION SYSTEM SERVICING – MAIN GEARBOX – DRAIN PLUGS



SAMPLE ECAM MESSAGES FOR ATA 79

CHAPTER 8

STARTING

ATA 80

SYMBOLS

Symbols used in this guide are explained below.


Special tooling is required.

LRU
The component is a Line Replaceable Unit (LRU).

PMT
A Post Maintenance Test is required.

WARNING
Avoid injury by following guidelines listed under this symbol.

CAUTION
Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of the Starting System.
2. Locate system components.
3. List the air sources to accomplish a ground start.
4. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Starting System provides the means for motoring the engine to starting rpm, whether on the ground or in flight.

Ground start can be accomplished using air supplied from an aircraft Auxiliary Power Unit (APU), from another engine, or from a Ground Power Unit (GPU).

The Starting System consists of the components below.

- Air Turbine Starter ATS
- Starter speed sensor
- Starter Air Valve SAV
- Starter air duct

The Full Authority Digital Electronic Control (FADEC) manages all aspects of engine starting and motoring, whether wet or dry. FADEC commands the SAV and the ignition exciter, and introduction of fuel into the burner, in response to aircraft command signals. The EEC controls operation through the flight deck engine start selector switch and the fuel run/off switch position.

In-flight windmill starts may require starter assistance in the form of APU or cross-bleed engine air, depending on N2 rotor speed and time since shutdown.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

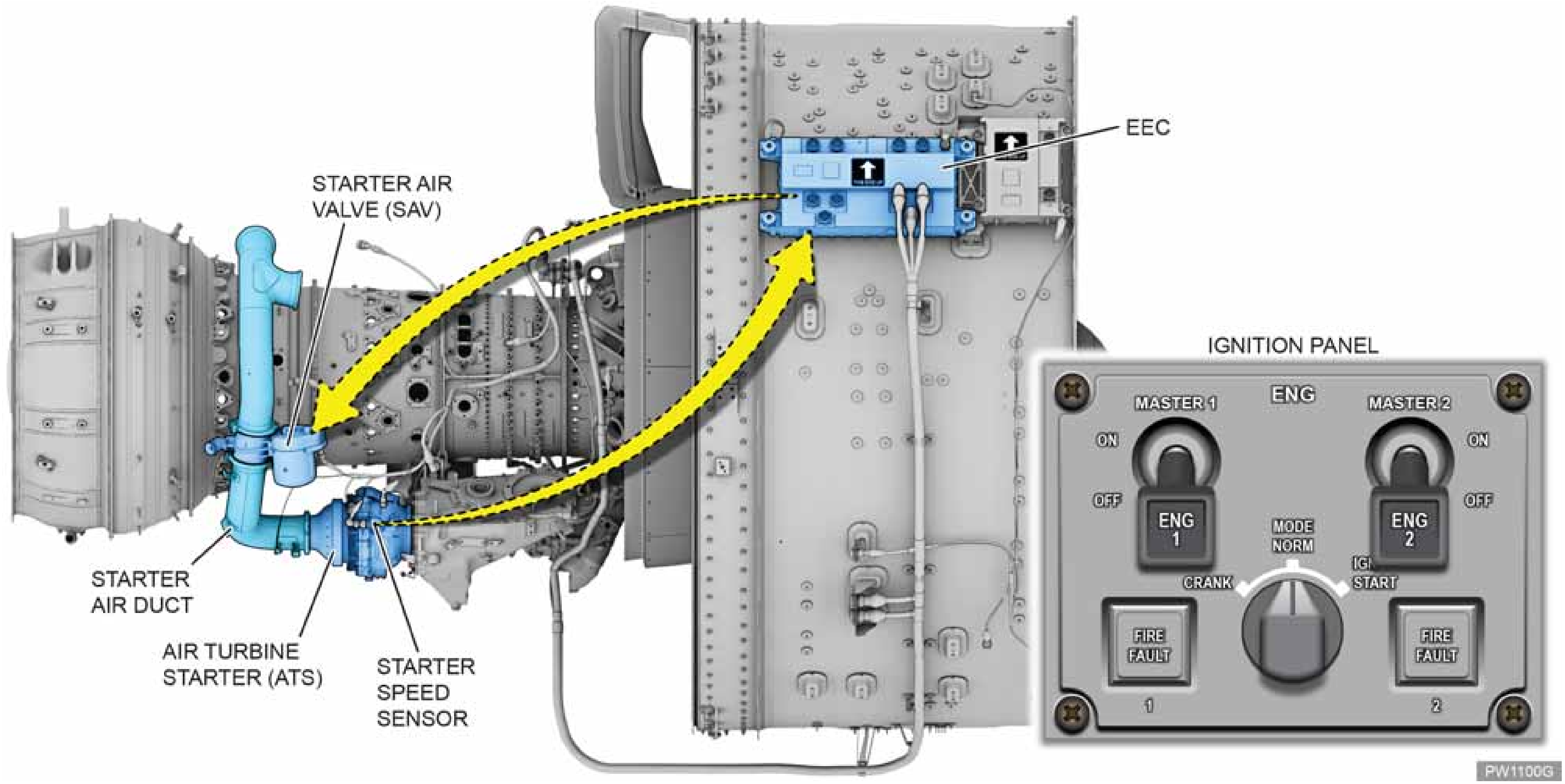
WHEN THE ENGINE OPERATES, MAKE SURE THAT ALL PERSONS WHO WORK NEAR THE AIRCRAFT USE EAR PROTECTION. THE LOUD NOISE FROM THE ENGINE CAN CAUSE TEMPORARY OR PERMANENT DAMAGE TO YOUR EARS IF YOU DO NOT USE EAR PROTECTION.

KEY FACT

Motoring is done for operational or maintenance purposes.

Dry motoring rotates the high turbine rotor with the fuel supply off. Dry motoring is accomplished by setting the start/ignition switch to CRANK.

Wet motoring rotates the high turbine rotor with the fuel supply on and the ignition system off. The ENG/MODE switch is set to NORM while the ENG/MASTER 1(2) control switch is set to OFF.



STARTING SYSTEM

COMPONENTS

Air Turbine Starter (ATS)

Purpose: LRU PMT

The Air Turbine Starter converts airflow to power in the form of torque that drives the Main Gearbox. The gearbox then applies this energy to rotate the HPC/HPT (N2) rotor.

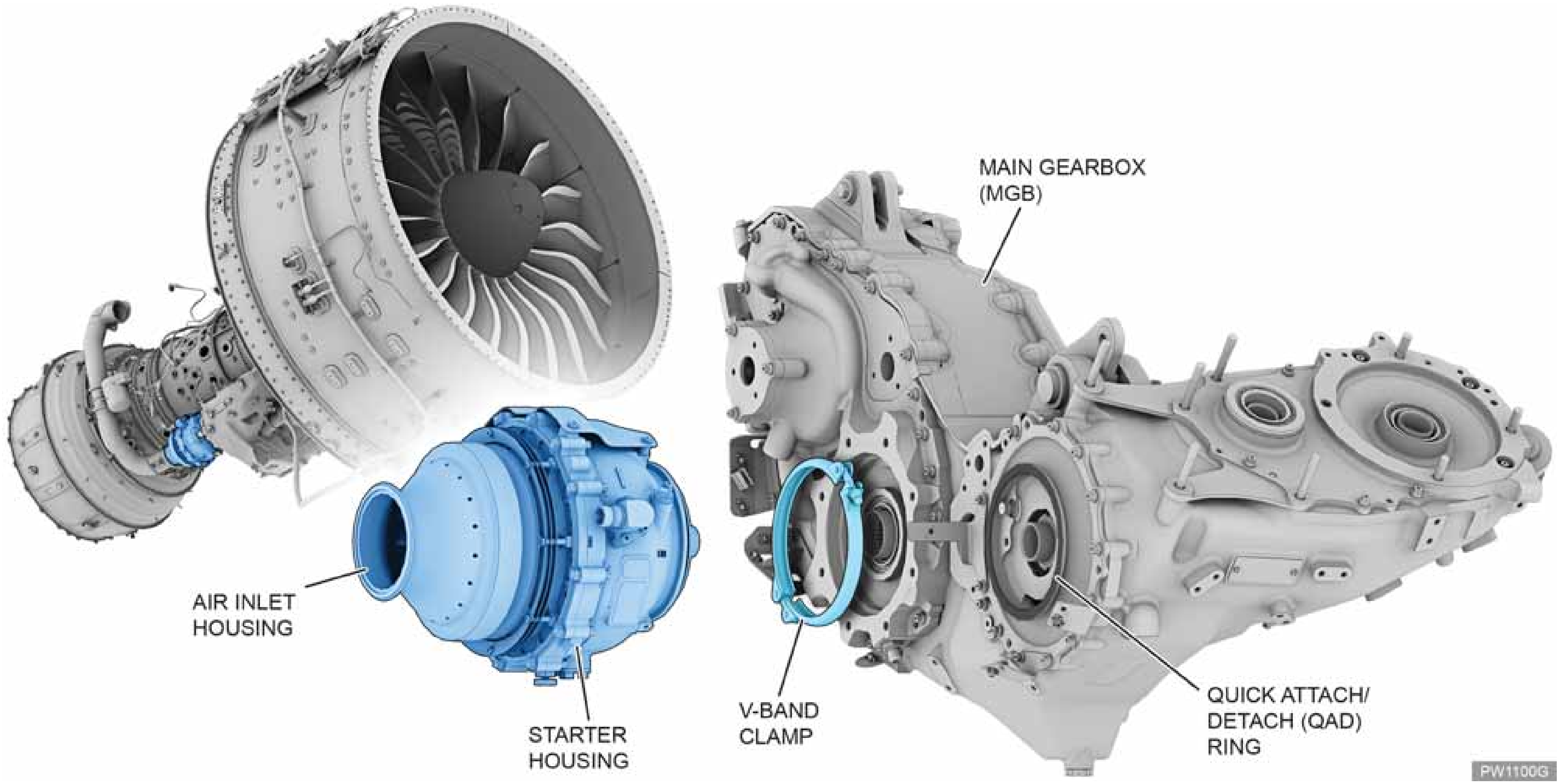
Location:

The starter is located on the rear right side of the Main Gearbox (MGB) at 5:00.

Description:

The starter is mounted to a Quick Attach/Detach (QAD) ring with a single V-band clamp. The QAD ring is mounted to the MGB.

The starter incorporates a single stage turbine wheel, single piece output shaft, and a ratchet and pawl clutch. The starter gears and bearing are splash lubricated from the engine Lubrication System. Fill and drain ports are provided on the housing for servicing.



AIR TURBINE STARTER (ATS)

COMPONENTS

Air Turbine Starter (ATS)

Description (Cont.):

A magnetic plug assembly consists of an inner magnetic probe and an outer fitting.

The inner magnetic probe can be removed to check for metallic chips without draining the oil. A check valve in the outer fitting prevents the loss of oil when the magnetic probe is removed. A starter speed sensor is provided to detect starter rotation and speed.

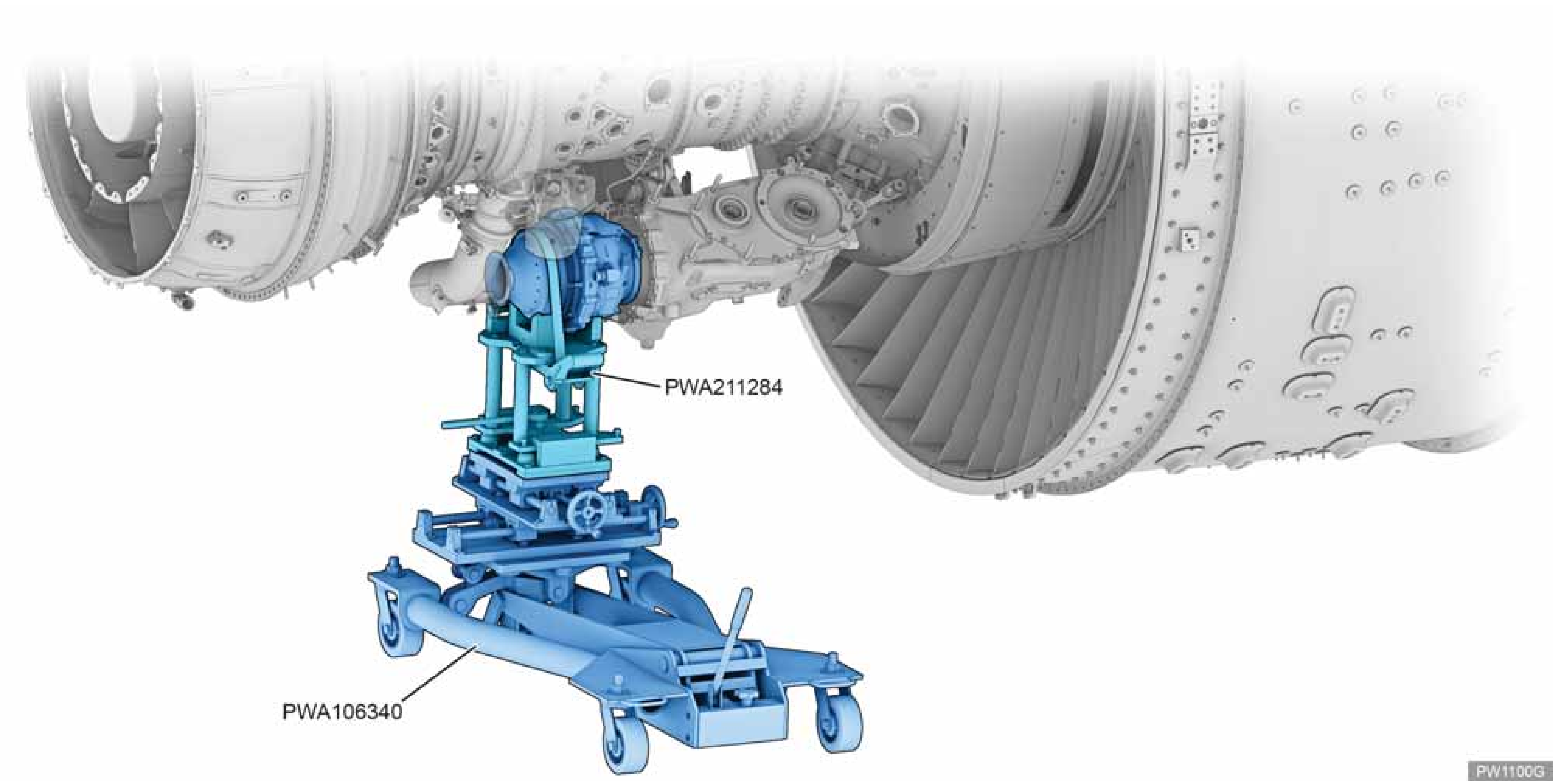
PWA211284 and PWA106340 are support equipment used for starter installation and removal.

Operation:

1. Air is provided by an external source, such as an Auxiliary Power Unit, Ground Power Unit, or cross bleed.

2. The air flows into the starter, spinning the turbine that is connected to the output shaft by means of a gear, ratchet, and pawl clutch.

3. This power is transmitted through the gearbox shafts to the N2 rotor. Once N2 reaches a sufficient speed, the starter clutch disengages the starter turbine from the output shaft.



AIR TURBINE STARTER – REMOVAL AND INSTALLATION TOOLS

COMPONENTS

Air Turbine Starter (ATS)

Operation (Cont.):

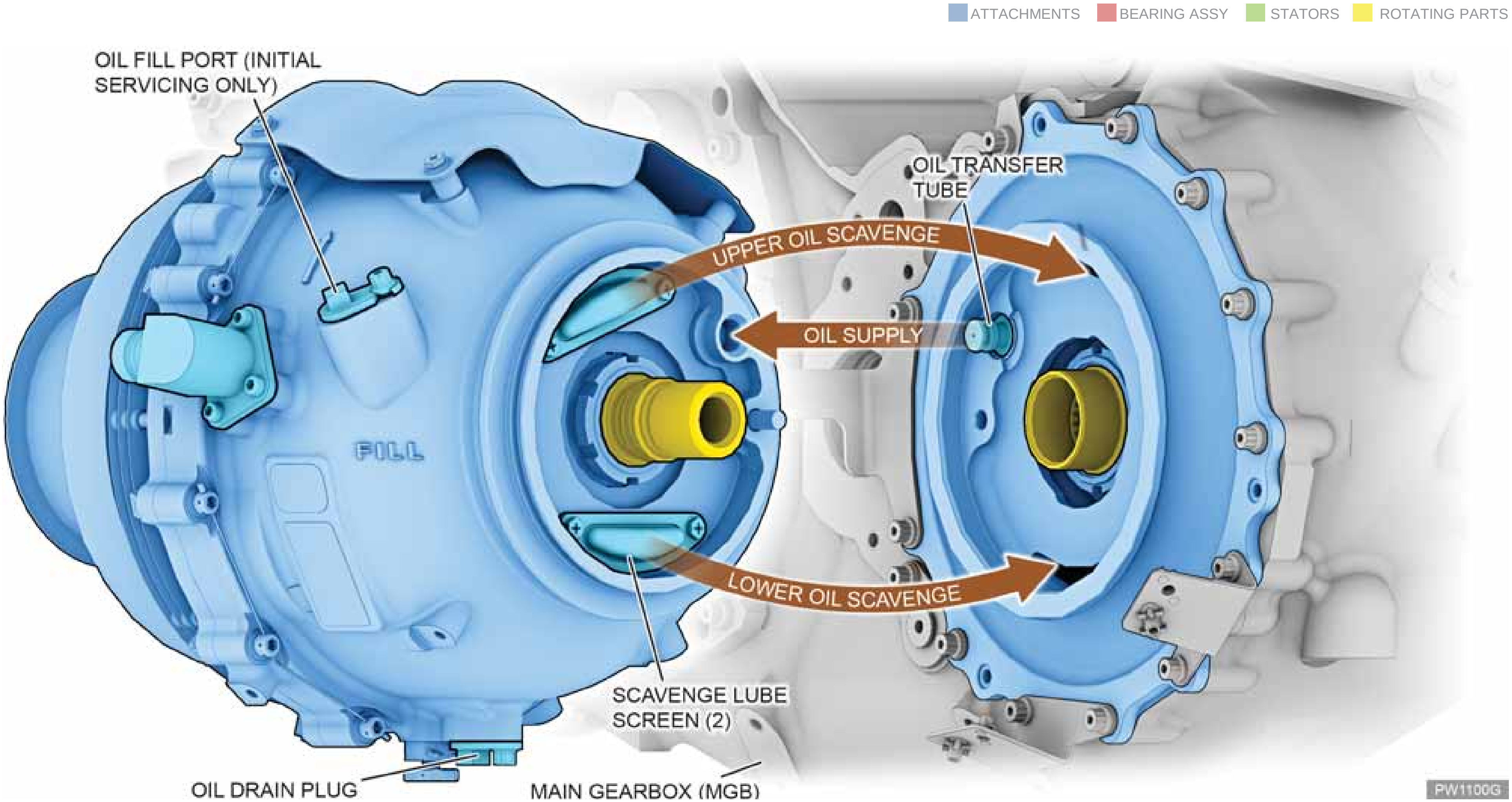
Starter Oil Distribution

The Air Turbine Starter uses the engine oil system to lubricate the starter gears and bearings. Oil from the MGB enters the starter through a transfer tube and is then distributed to the bearings through internal oil passages.

Oil jets direct the flow of oil to the bearings. An oil slinger lubricates the gears. Oil from the bearings and gears is scavenged back to the MGB through two screens.

When a new or an overhauled starter unit is installed, a small quantity of oil needs to be added through the fill port in the inlet housing. This ensures that the bearing and gears are sufficiently lubricated during the first engine start.

A drain plug in the housing allows for draining the oil prior to removal of the ATS.



AIR TURBINE STARTER – STARTER OIL DISTRIBUTION

COMPONENTS (Cont.)

Starter Speed Sensor

Purpose: LRU PMT

The starter speed sensor provides the EEC with a speed signal that is used to determine whether the starter is rotating.

Location:

The sensor is located on the ATS housing at 3:00.

Description:

The starter speed sensor is a one-piece, hermetically sealed unit consisting of a dual-channel magnetic speed sensor, utilizing a single permanent magnet, two separate coils and one electrical connector. It supplies input to both A and B channels.

An electrical signal transmitted from the sensor is sent to the EEC for detection of fail conditions that could include:

- SAV failure in open position during start
- uncommanded opening of SAV after start
- shearing of starter drive shaft.

Operation:

1. The starter speed sensor detects the starter ring gear speed by detecting each tooth as it passes the tip of the magnetic probe. The teeth of the ring gear produce a change in the magnetic field as they pass the face of the magnet.
2. The time-varying electrical pulse signal is processed by the EEC and converted to a rotational speed.
3. This rotational speed is compared with EEC input from N2 to determine if the starter has failed.

STARTER SPEED SENSOR

COMPONENTS (Cont.)

Starter Magnetic Chip Collector

Purpose:

The starter magnetic chip collector detects metal particles generated by the starter.

Location:

The chip collector is located at 6:00 on the starter housing.

Description:

The starter magnetic chip collector consists of an inner magnetic plug that can be removed to check for metallic chips without draining the oil.

A check valve in the outer fitting prevents loss of oil when the magnetic plug is removed.

Safety Conditions

CAUTION

INSTALL THE CHIP COLLECTOR VALVE APART FROM THE CHIP COLLECTOR PROBE. DO NOT TORQUE THE VALVE TOO MUCH. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN DAMAGE THE CHIP COLLECTOR ASSEMBLY.

MAKE SURE THE WORK AREA YOU EXAMINE THE STARTER MAGNETIC CHIP COLLECTOR IN IS FREE FROM CONTAMINATION. CONTAMINATION OF STARTER MAGNETIC CHIP COLLECTOR CAN OCCUR IF YOU PUT THE STARTER MAGNETIC CHIP COLLECTOR ON A DIRTY WORK BENCH, ON THE GROUND, OR IN A TOOL BOX.

STARTER MAGNETIC CHIP COLLECTOR

COMPONENTS (Cont.)

Starter Air Valve (SAV)

Purpose: LRU PMT

The Starter Air Valve ports duct air to the Air Turbine Starter on EEC command.

Location:

The SAV is next to the High Pressure Turbine case at 4:00.

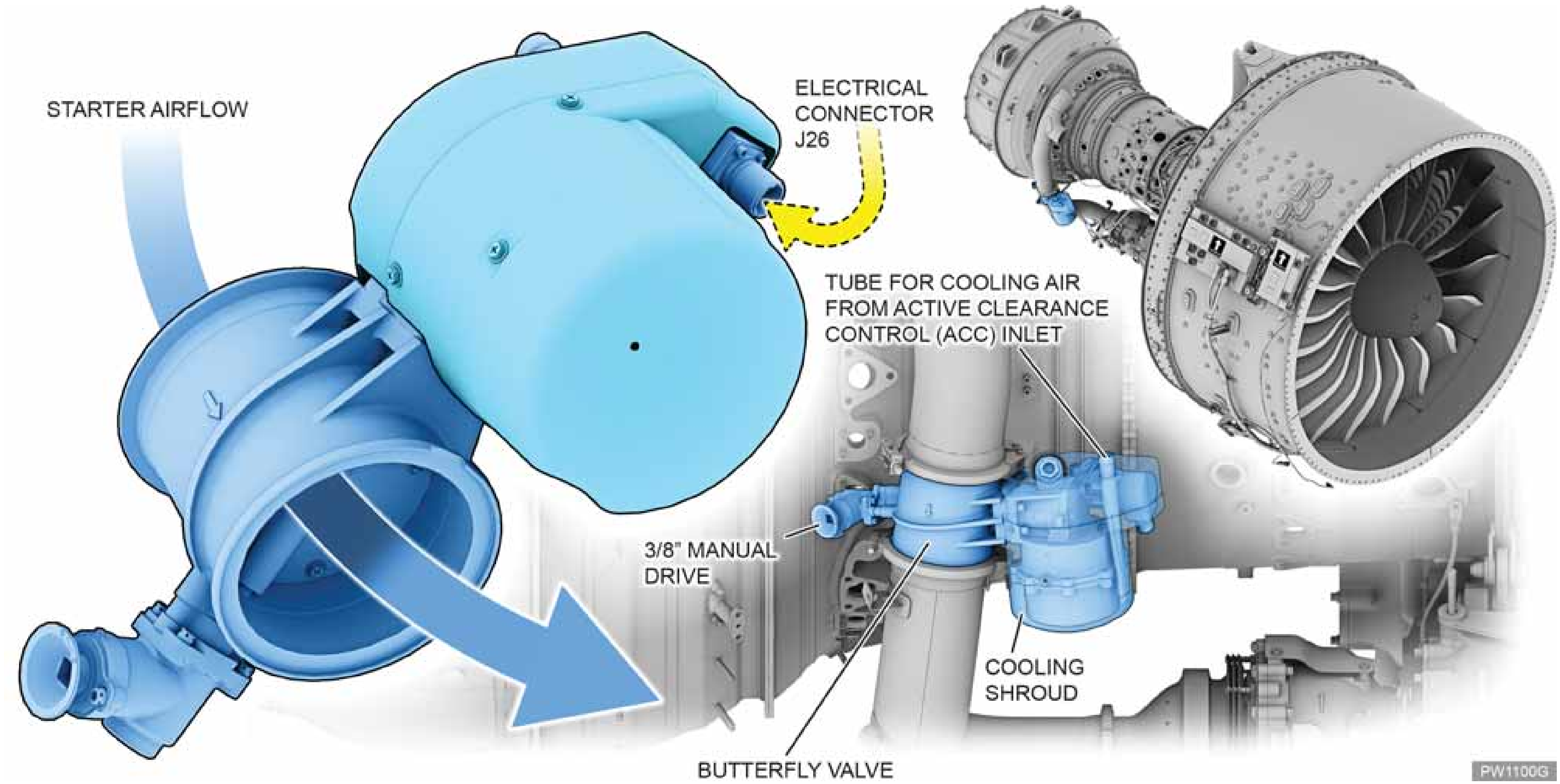
Description:

The SAV is a butterfly valve that is pneumatically actuated and solenoid controlled. It is connected to upper and lower starter air ducts with V-band clamps.

The valve is equipped with a cooling shroud to protect temperature-sensitive parts. A cooling tube supplies fan bypass air to the shroud.

A $^3/_8$-inch-square drive is provided for manual override capability.

The valve fail-safe position is closed.



STARTER AIR VALVE (SAV)

COMPONENTS

Starter Air Valve (SAV) (Cont.)

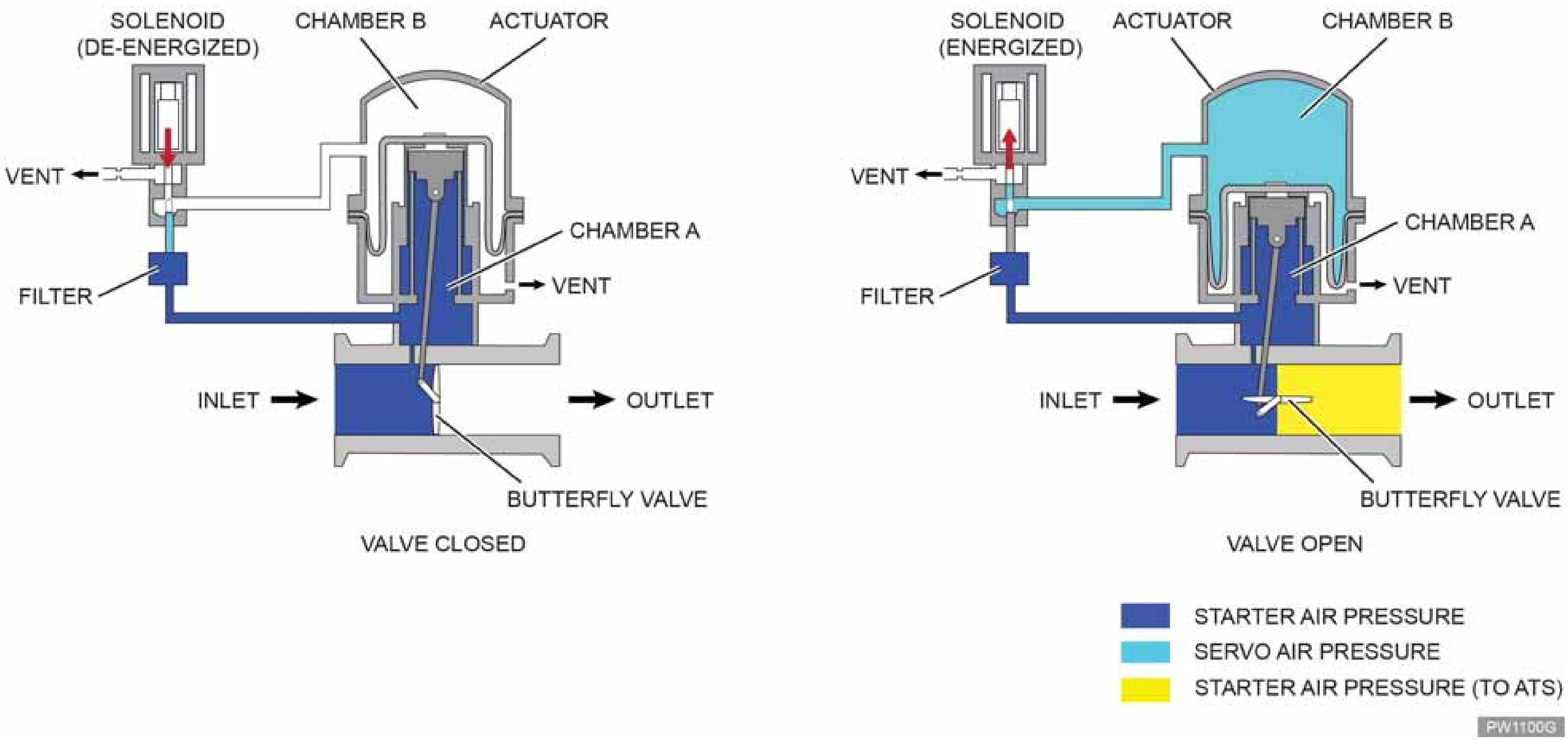
Operation:

The EEC commands the valve open or closed using a dual-coil SAV solenoid. It provides discrete (on/off) control of starter air pressure sent to the SAV actuator to open and close the SAV. Valve position is determined by the starter speed signal to the EEC.

When the solenoid is de-energized, the valve is closed, shutting off the air pressure to the actuator and holding the butterfly valve in the closed position by the spring. When the solenoid is energized, the valve is open, allowing air pressure to flow to the backside of the actuator piston (Chamber B).

During manual operation there must be duct pressure before opening. The valve should be opened and closed slowly to prevent damage.

During hot engine starts, the SAV is used in a modulating mode to achieve low speed motoring to cool the HPC rotor to decrease the chances of blade rubbing in the HPC. Once the engine has cooled, a normal engine start can be conducted.



STARTER AIR VALVE (SAV) OPERATION

COMPONENTS (Cont.)

Starter Air Duct

Purpose: LRU PMT

The starter air duct is a flow path for pressurized air that turns the pneumatic starter.

Location:

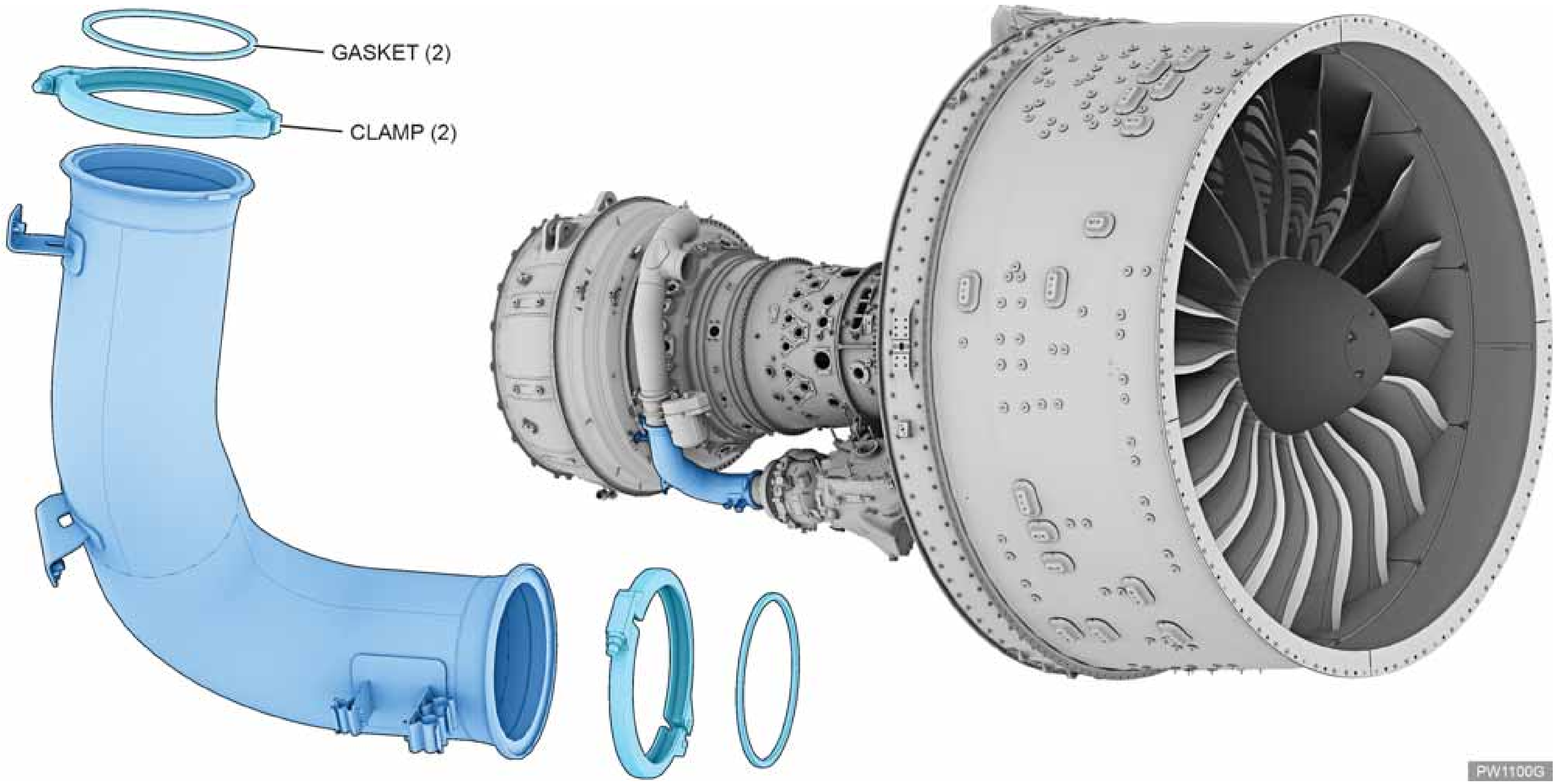
The duct is located aft of the starter at 8:00.

Description:

The duct is made of welded metal with flanges on either end and is attached with clamps to the Air Turbine Starter and Starter Air Valve.

Gaskets are placed between the flanges of the duct and the component to eliminate air leakage. The duct has an air fitting mounted to it for a pneumatic control line.

The duct must be removed for starter replacement.



STARTER AIR DUCT

SYSTEM OPERATION

Air supply to the starter is controlled by the Starter Air Valve (SAV). The valve is opened and closed automatically by the EEC or manually by the flight/maintenance crew. Mode of operation is chosen through the manual or automatic start knob selector position, and the engine fuel cutoff ON/OFF switch.

During engine start, the spring-loaded HPC passive and active bleed valves allow HPC 6th Stage air to bleed directly into the core compartment to help with initial compression of upstream core air flow.

Autostart

An automatic start sequence is controlled by the FADEC. During automatic start the crew will first move the ENG/MODE switch to IGN/START, which energizes both ignition systems. The ENG MASTER 1 (2) master switch is switch to ON, which begins the engine start sequence. The crew will then monitor the engine parameters on ECAM. Once idle speed is reached, the crew will then move the ENG/MODE switch to NORM.

Engine idle speeds will vary by condition. N1 ground idle speed is approximately 19 percent. N2 ground idle speed is approximately 59 percent.

Safety Conditions

WARNING

MAKE SURE THAT ALL ENGINE OPERATING AREAS ARE AS CLEAN AS POSSIBLE. ALL RAMPS, TAXIWAYS, RUNWAYS, AND OTHER OPERATING AREAS MUST BE VERY CLEAN TO PREVENT DAMAGE TO THE ENGINE OR AIRCRAFT AND INJURY TO THE PERSONS IN THE AREA.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

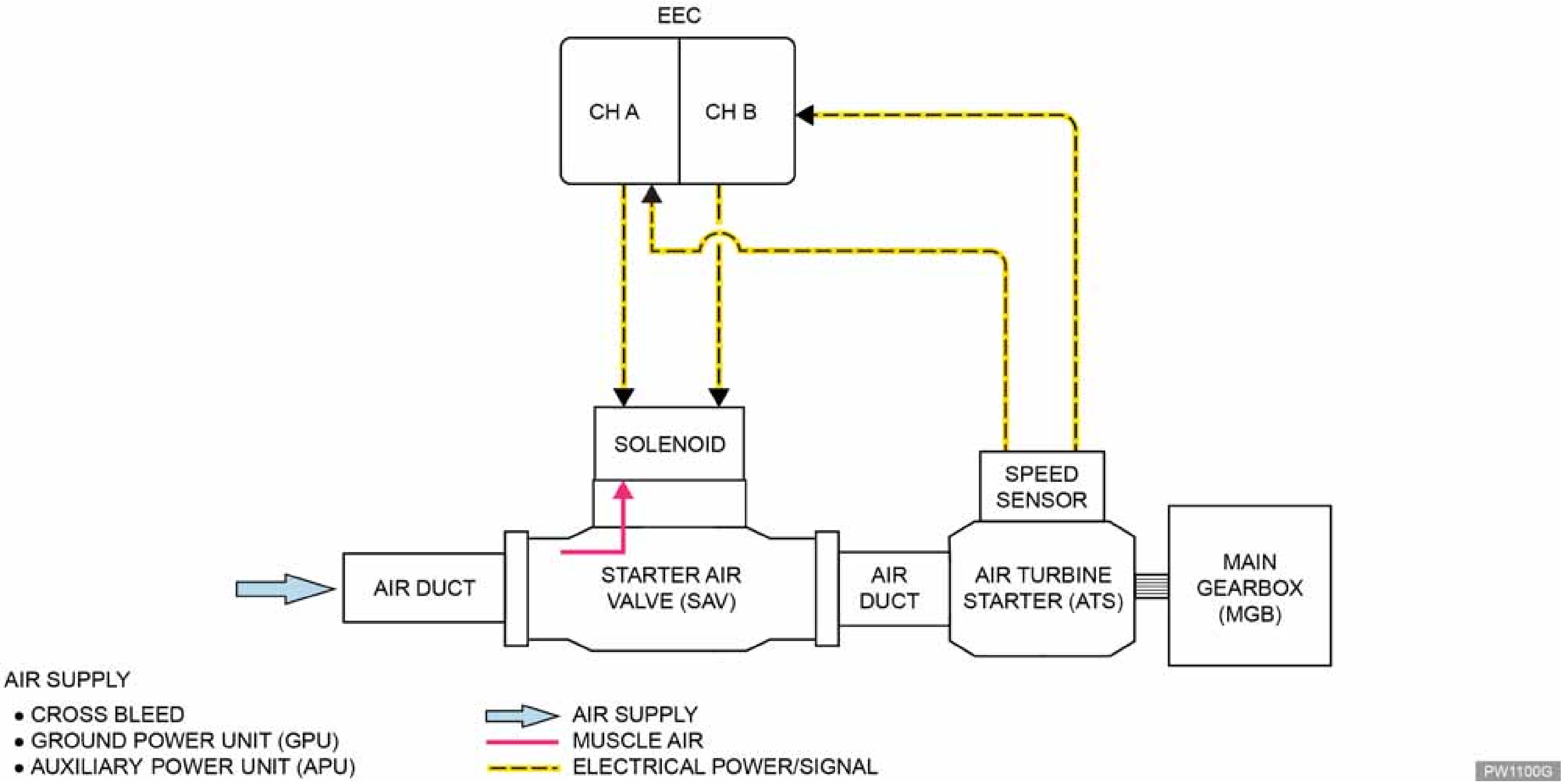
SET THE THRUST LEVERS TO IDLE BEFORE YOU START THE ENGINE. IF YOU DO NOT DO THIS, THE THRUST LEVEL WILL RAPIDLY INCREASE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

YOU MUST DO ALL OF THE STEPS IN THE START PROCEDURE AND FOLLOW IN THE CORRECT SEQUENCE. IF YOU DO NOT OBEY THIS CAUTION, A HOT OR HUNG START CAN RESULT.

DO NOT LET FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

If the engine is hot when the start sequence is commanded, the FADEC will automatically motor the N2 rotor at a low speed (approximately 10 percent) to cool the engine first. The ECAM will display an ENGINE COOLING message at this time with a timer for the cooling sequence.



STARTING SYSTEM OPERATION

SYSTEM OPERATION (Cont.)

Manual Start

If an electrical or mechanical failure occurs, the SAV can be manually opened and closed on the ground by maintenance personnel.

A manual start sequence is controlled by the crew. During manual start, the crew will first move the ENG/MODE switch to IGN/START, which energizes both ignition systems. The ENG/MAN START/1(2) pushbutton is then pushed to ON, which opens the Starter Air Valve. Once the N2 speed has reached its maximum motoring value (approximately 18% N2), the ENG MASTER 1 (2) master switch is switch to ON. The crew will then monitor the engine parameters on ECAM. Once idle speed is reached, the crew will push the ENG/MAN STRT/1(2) pushbutton to OFF. The crew will then move the ENG/MODE switch to NORM.

Engine idle speeds will vary by condition. N1 ground idle speed is approximately 19 percent. N2 ground idle speed is approximately 59 percent.

If the engine is hot when the start sequence is commanded, the FADEC will automatically motor the N2 rotor at a low speed (approximately 10 percent) to cool the engine first. The ECAM will display an ENGINE COOLING message at this time with a timer for the cooling sequence.

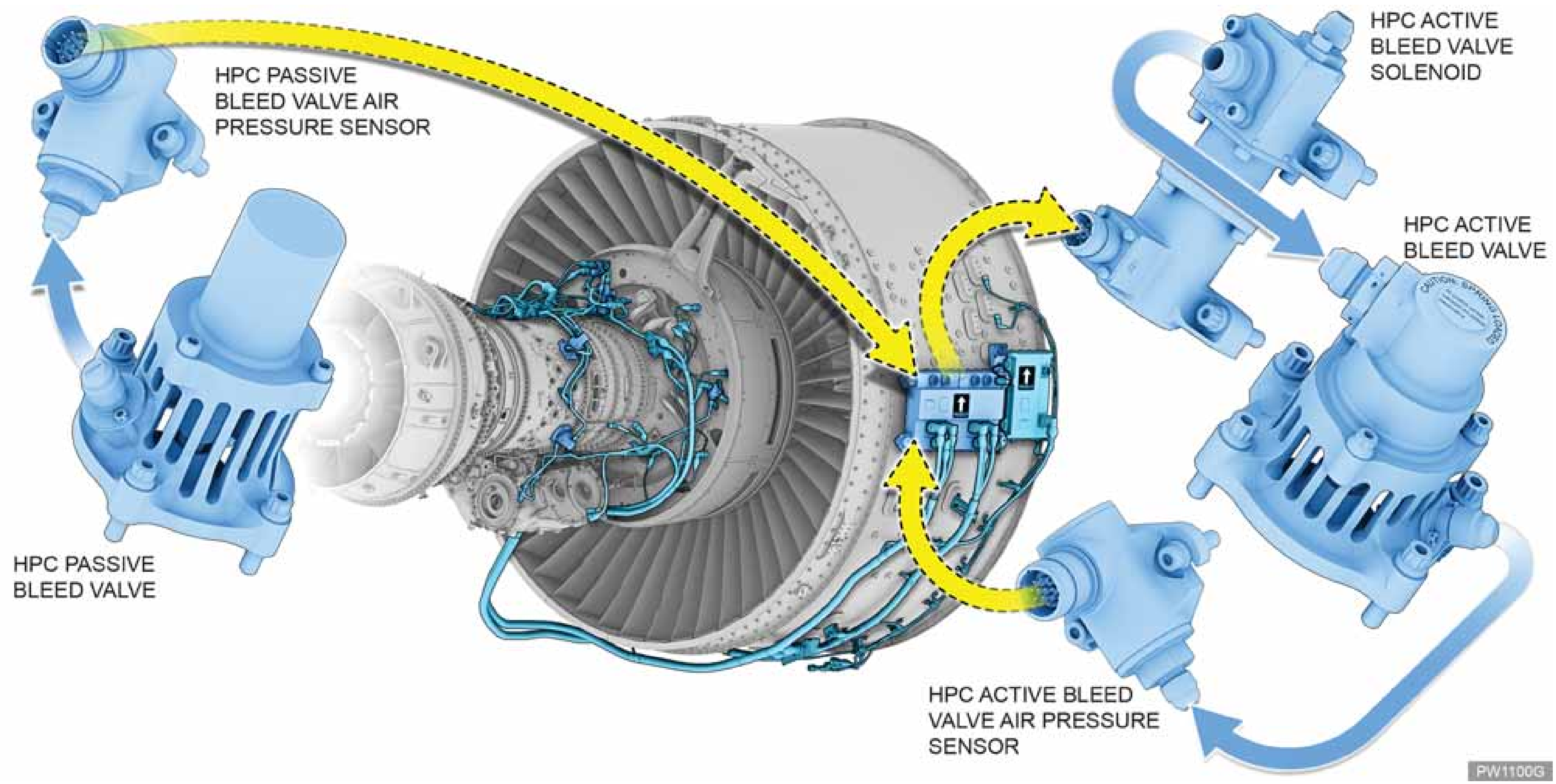
SYSTEM OPERATION (Cont.)

Start Bleed for HPC Passive and Active Bleed Valves

1. At start, some of the 6th Stage HPC air travels through tubes that are connected to the HPC active and passive bleed valve pressure sensors. When there is pressure in the tubes, the pressure sensors send an electronic signal to the EEC indicating that the valves are open.

2. When pressure at the 6th Stage of the HPC is high enough to overcome the spring load of the valve at sub-idle, the HPC passive bleed valve is pushed closed.

The HPC active bleed valve operates by the same principle, except it is kept open for a longer duration. An EEC-controlled solenoid provides pneumatic muscle pressure to assist the spring load in keeping the active valve open until the engine reaches idle power.

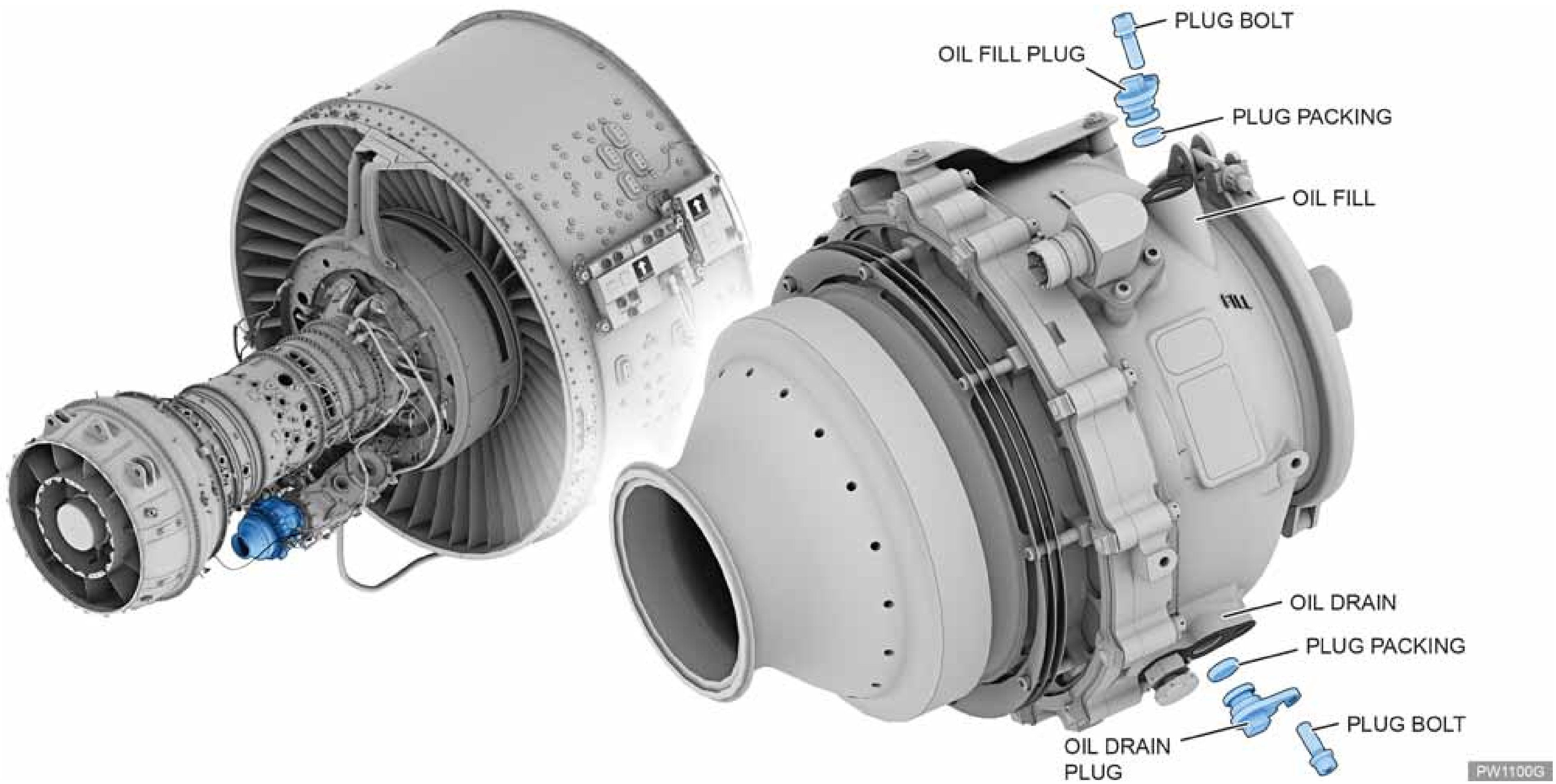


STARTER SYSTEM – START BLEED OPERATION

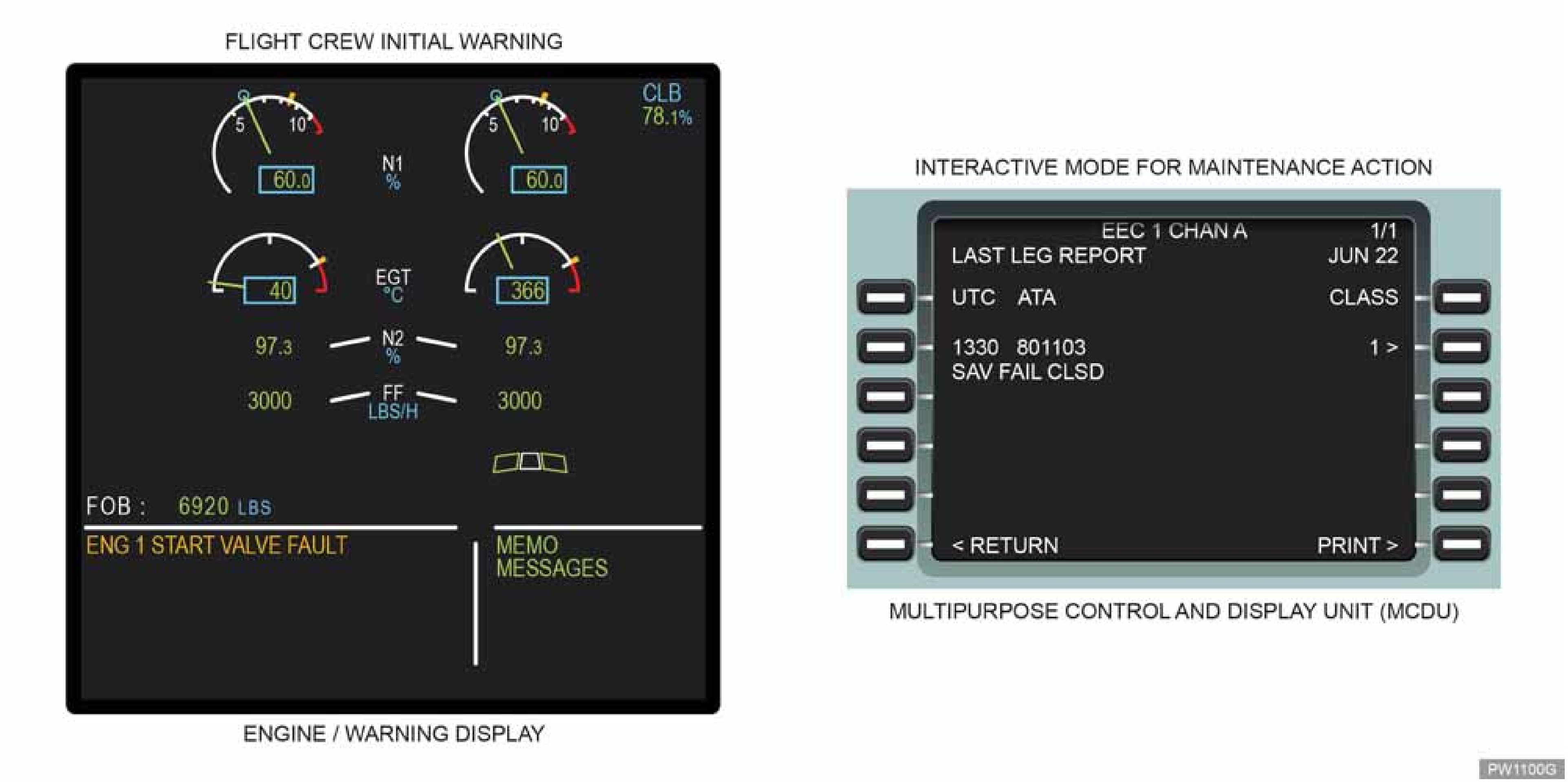
AIR TURBINE STARTER (ATS) SERVICING

Initial Service of Starter Oil

1. Put the fluid drain collector/container (approximately 5 gallons/20 L) under the starter to catch the starter oil.
2. Loosen the fill plug retention bolt on the starter.
3. Turn the fill plug to disengage the retention tab from under the bolt.
4. Hold the fill plug by the square, then turn and pull it as necessary to remove it from the starter.
5. Remove and discard the packing.
6. Fill the starter with 16–20 oz. of the engine oil.
7. Apply engine oil to a new preformed packing.
8. Install the preformed packing on the fill plug.
9. Install the fill plug.
10. Make sure the fill plug is fully seated against the mating surface of the starter housing.
11. Torque the fill plug retention plug per the Aircraft Maintenance Manual (AMM).
12. Make sure that the work area is clean and clear of tools and other items.



STARTER SYSTEM SERVICING



SAMPLE ECAM MESSAGE FOR ATA 80

CHAPTER 9

EXHAUST

ATA 78

SYMBOLS

Symbols used in this guide are explained below.

	Special tooling is required.
LRU	The component is a Line Replaceable Unit (LRU).
PMT	A Post Maintenance Test is required.
WARNING	Avoid injury by following guidelines listed under this symbol.
CAUTION	Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of the Exhaust System.
2. Locate system components.
3. Tell how key components maximize thrust for the engine.
4. Identify Line Replaceable Units (LRUs).

OVERVIEW

The Exhaust System is made up of nacelle components that form a flow path directing the air from the engine core and the engine fan. The shape of the nacelle is optimized to minimize drag and to maximize thrust from the engine.

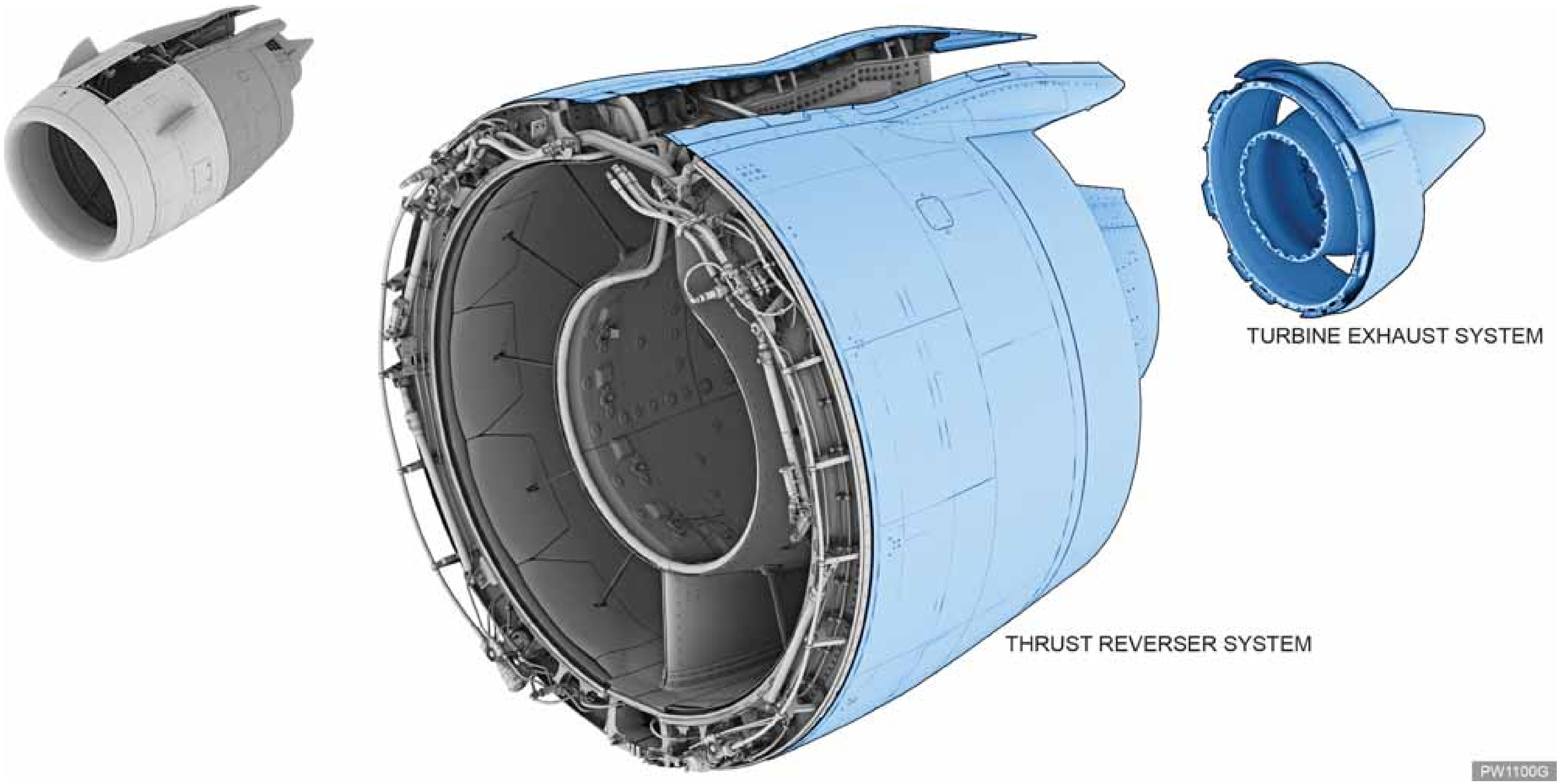
The Exhaust System is made up of two subsystems, shown below.

Thrust Reverser System

The Thrust Reverser System protects the engine core, forms a path for fan bypass air and deploys to slow the aircraft upon landing.

Turbine Exhaust System

The Turbine Exhaust System makes the path for the turbine gases exiting the engine core. It gives direction to the turbine gases, which helps to increase thrust and reduce turbulence.



EXHAUST SYSTEM – THRUST REVERSER AND TURBINE EXHAUST SYSTEMS

THRUST REVERSER SYSTEM

The Thrust Reverser System provides the aerodynamic braking for the aircraft on the ground. Reverse thrust reduces the distance the aircraft needs to safely and efficiently stop during a landing or aborted take-off. During taxi and flight the reverser provides an efficient flow path that sends air aft for maximized thrust.

Thrust reverser cowls are attached to the pylons on the left and right sides of the engine.

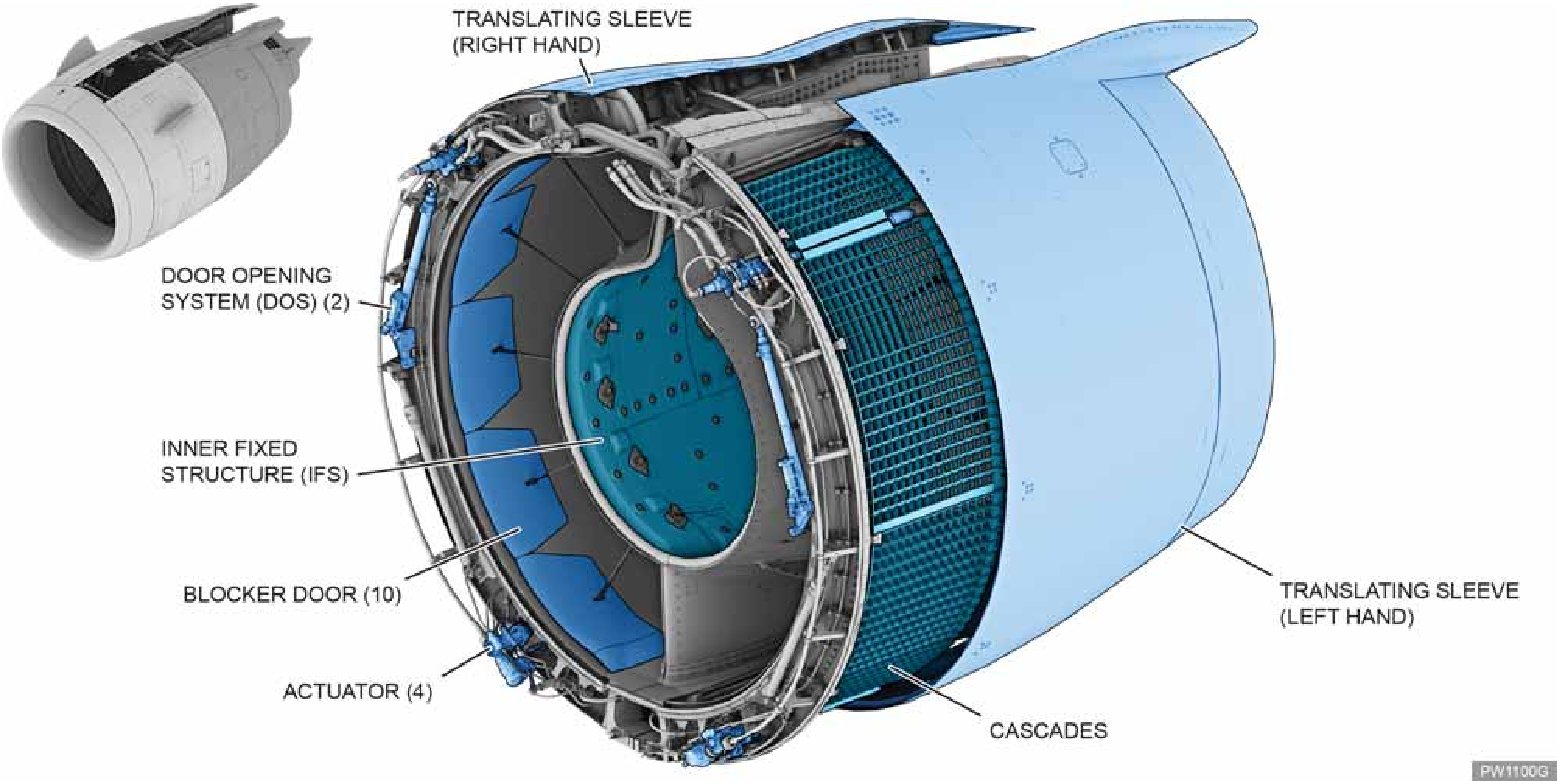
Some major system components are shown below.

- Translating sleeve (2)
- Blocker doors (10)
- Inner Fixed Structure IFS
- Cascade array
- Hold Open Rods HORs
- Thrust Reverser Actuation System TRAS
- Door Opening System DOS

The thrust reverser is composed of two halves that are mechanically independent. The halves hinge at the pylon, latching together along the bottom split line.

An Inner Fixed Structure (IFS) provides thrust reverser support and protects the engine's core cases and externals. The IFS forms the inner surface of the duct for fan bypass air.

An outer structure that includes a translating sleeve and blocker doors forms the outer surface of the fan bypass air duct. The outer fan duct translating sleeve is normally stowed, providing uninterrupted fan air flow aft and producing the required thrust from the fan.



THRUST REVERSER SYSTEM (1 OF 2)

THRUST REVERSER SYSTEM (Cont.)

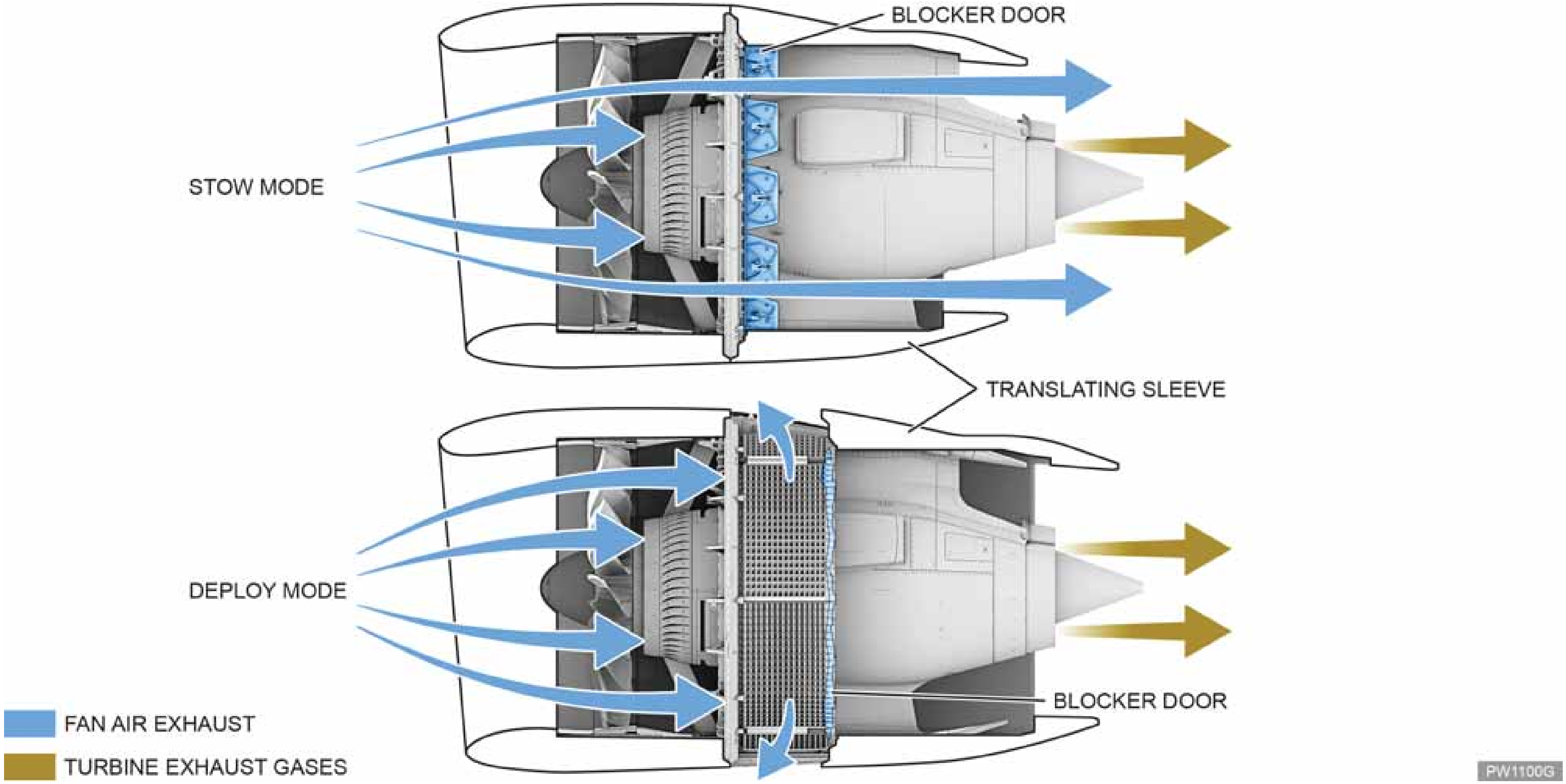
Upon landing, the thrust reverser is deployed, moving the translating sleeve aft and allowing blocker doors to rotate to a vertical position and block the fan air. This action redirects the fan airflow through the thrust reverser cascades, sending it forward and outward in a controlled pattern that provides reverse thrust to help decelerate the aircraft.

The Thrust Reverser Actuation System (TRAS) is composed of two hydraulic linear synchronized actuators per side. The actuators deploy and stow the reverser. Reverser operation is controlled by the EEC.

For ease in opening and closing, thrust reverser cowls are equipped with a Door Opening System (DOS).

KEY FACT

The thrust reverser cowl can be switched between engines only when a cascade change is made to match the new position.



THRUST REVERSER SYSTEM (2 OF 2)

THRUST REVERSER SYSTEM (Cont.)

Translating Sleeves

Purpose:

Translating sleeves are the part of the thrust reverser doors that move to expose the cascades. The sleeves also close the blocker doors when the thrust reversers are deployed, which helps to slow the aircraft.

Location:

Two translating sleeves run aft of the engine fan case from the hinge beam to the latch beam of the IFS Assembly.

Description:

The translating sleeves make up the transcowl assembly. Each translating sleeve is constructed of a stiff, composite outer panel with an integrated copper mesh for lightning protection. The inner panel forms part of the bypass duct and is itself formed by the blocker doors and acoustic panel.

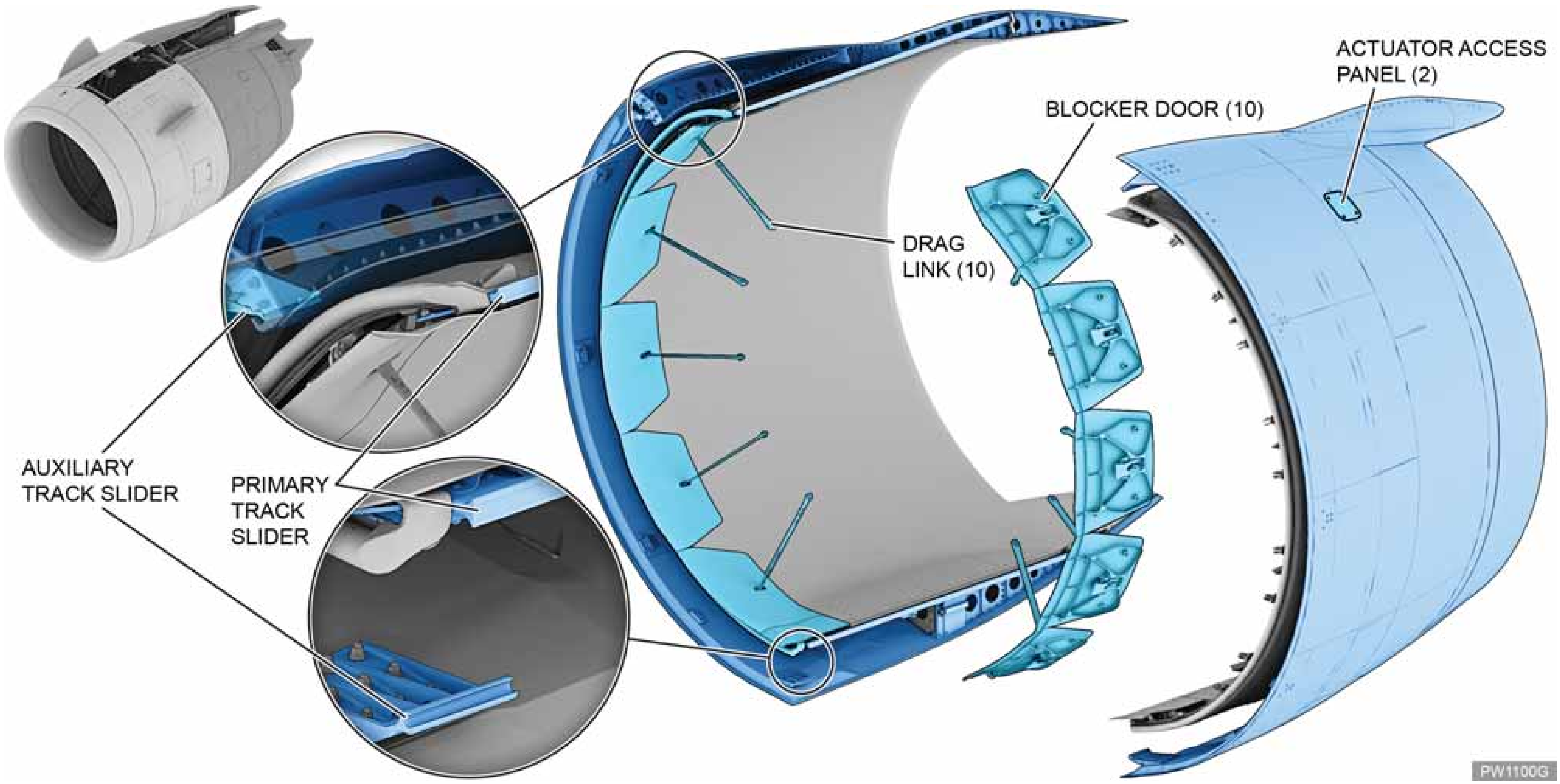
Blocker doors redirect fan duct flow through the thrust reverser cascades. The doors also form part of the outer fan duct's aerodynamic surface, as well as the acoustic lining of the outer fan duct wall.

A total of 10 blocker doors are used for a single thrust reverser, 5 per cowl half. The upper and lower doors are unique in size and cannot be installed into any other position.

Two access panels are attached to the translating sleeve. They provide access to fasteners that attach the TRAS actuators to the translating sleeve assembly.

Auxiliary track sliders are attached to the upper and lower ends of the forward-most stiffener of the outer panel. The sliders interface with the integral slide tracks on the hinge and latch beams, and provide the support structure for the cowl lock fitting.

The inner panel of the translating sleeve is a composite acoustic panel with acoustic treated skin. The inner panel also supports the primary track sliders for the transcowl, which are mechanically attached to the inner panel. The inner panel has attach points for blocker doors and drag links, and integrated copper mesh for lightning protection.



THRUST REVERSER SYSTEM – TRANSLATING SLEEVES

THRUST REVERSER SYSTEM

Translating Sleeves (Cont.)

Operation:

Drag links aid in rotating and positioning the blocker doors into the fan duct, redirecting airflow through the thrust reverser cascades.

1. During activation of the thrust reverser, the translating sleeve slides aft.

2. As it slides, the blocker doors start to lift and rotate about their hinges due to the drag links attached to both the door and the Inner Fixed Structure.

3. Once the sleeve is fully deployed, the doors will be in their full upright position.

THRUST REVERSER SYSTEM (Cont.)

Inner Fixed Structure (IFS)

Purpose:

The inner surface of the thrust reverser is formed by the IFS, which provides thrust reverser hoop continuity and reacts to surge and burst pressures through the bumpers, latches, and hinges.

Location:

The IFS covers the engine core, defines the core ventilation and fire zone, and forms the fan duct inner aerodynamic surface from the fan case exit to the core nozzle.

Description:

The IFS is a one-piece, adhesively bonded graphite fiber sandwich panel with a honeycomb core, forming the IFS bond panel assembly. Thermal blankets are attached to the whole inner side of the IFS and provide a barrier against the hot engine compartment.

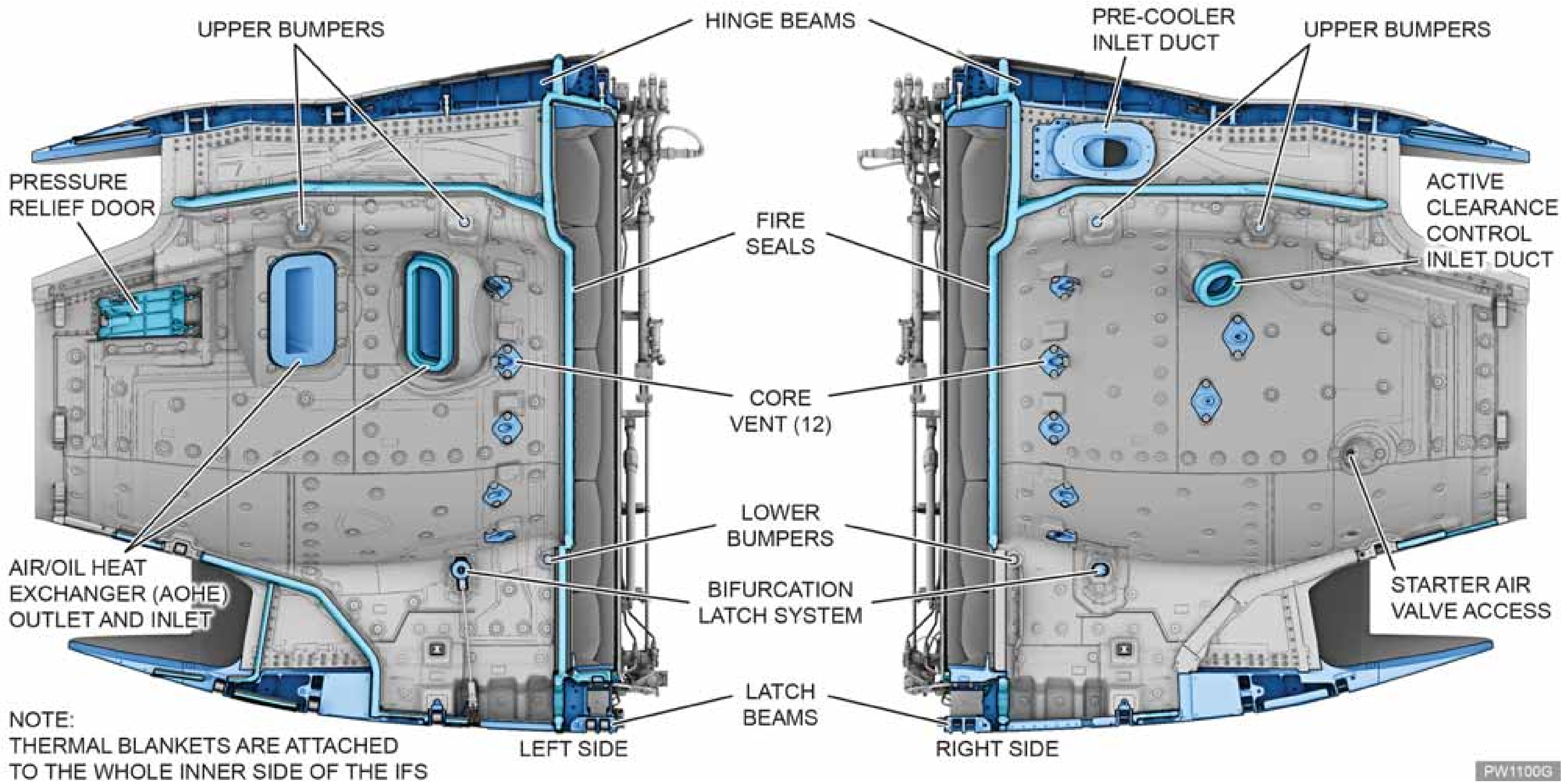
The aft core cowl defines bypass exit area, provides a close-out to the IFS bond panel, and reacts to the crush and burst pressures through hoop loading.

Inner Fixed Structure components are shown below.

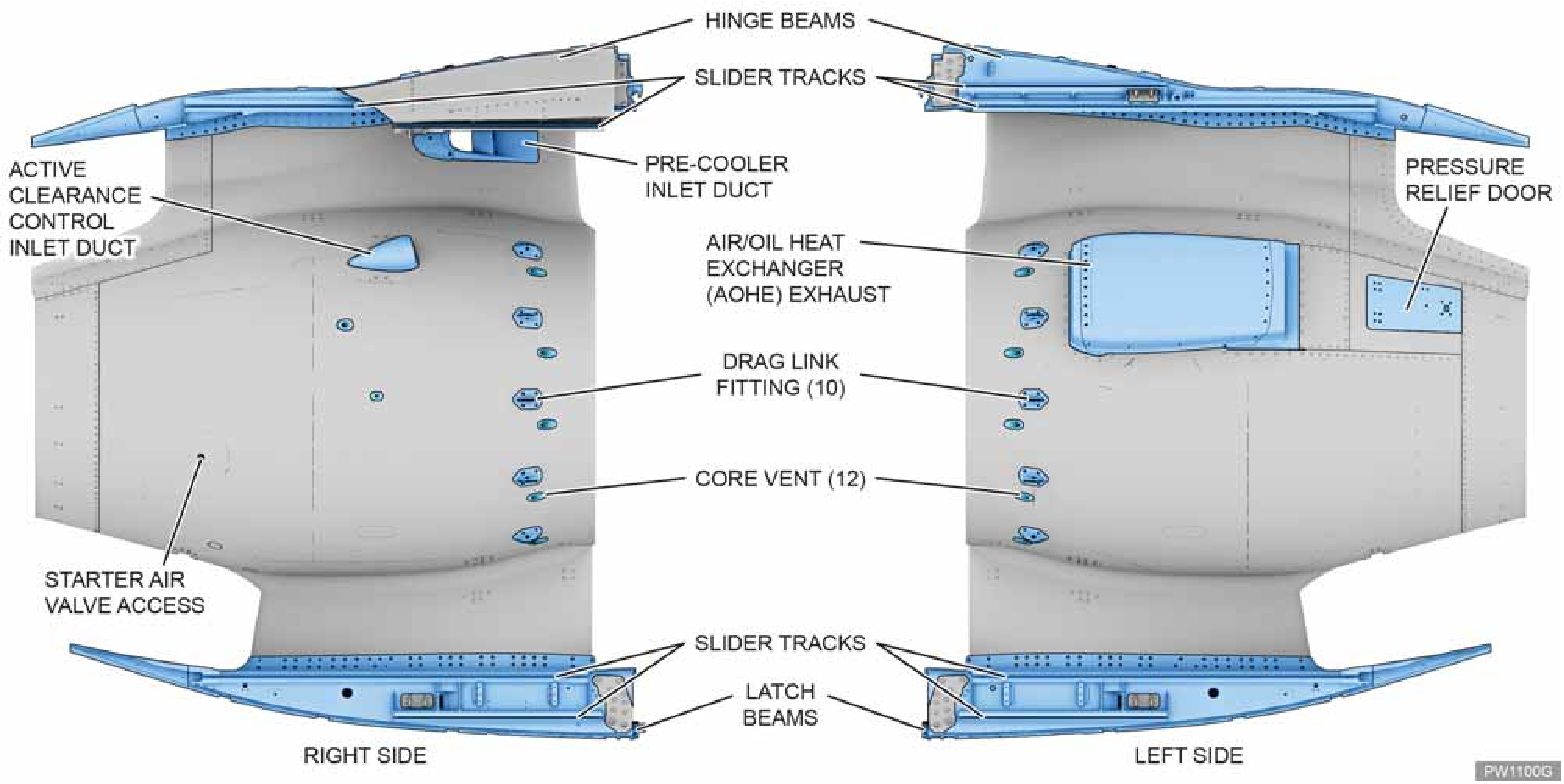
- Hinge beams (left and right side)
- Latch beams (left and right side)
- Fire seals (2 per side)
- Pressure relief door
- Bumpers (2 upper and 1 lower per side)
- Pre-cooler inlet duct
- Active Clearance Control inlet duct
- Bifurcation Latch System BLS

Operation:

Reverse thrust loads from the drag link fittings are transferred to a one-piece inner V-blade attached to the IFS panel.



THRUST REVERSER SYSTEM – INNER FIXED STRUCTURE – INNER SURFACE COMPONENTS



THRUST REVERSER SYSTEM – INNER FIXED STRUCTURE – OUTER SURFACE COMPONENTS

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Hinge Beams

Purpose:

The hinge beams provide a structural connection between the IFS and transcowl through two tracks integrated into the beams.

Location:

The beams attach directly to the IFS and interface with the transcowl via the primary and auxiliary tracks integrated into the beams.

Description:

The aluminum hinge beam extends the length of the upper bifurcation and connects the two reverser halves to the pylon via three hinge beam clevises and one floating hinge.

The hinge beam incorporates the features below.

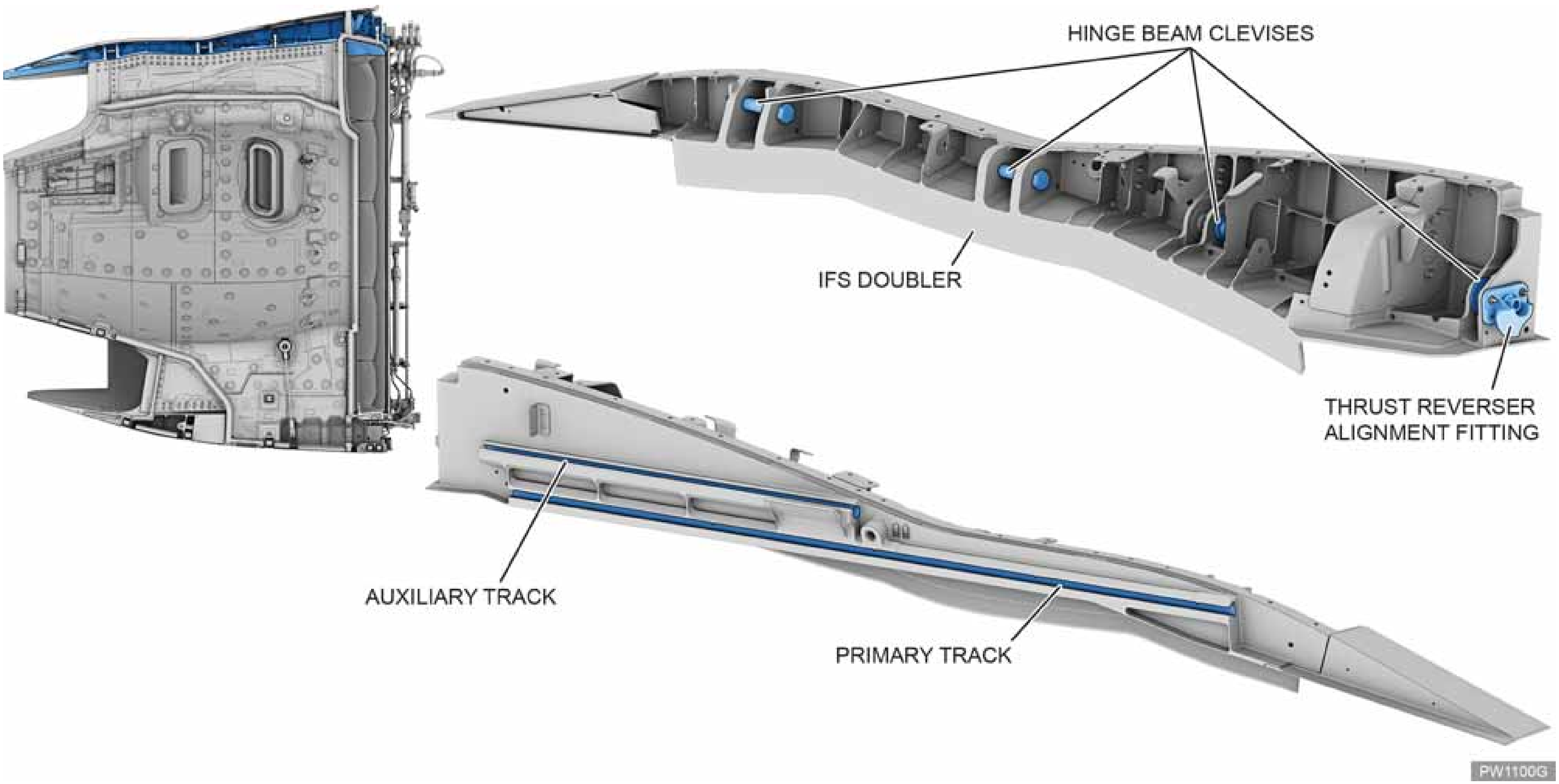
- Primary track and auxiliary track sliders for installation of the translating cowl
- Attachment of the cascade aft support ring
- Provision for the attachment of hinge line fairings

Operation:

The integrated tracks provide a means for the sleeve to slide during deployment of the reverser. Additionally, the beams react to hoop and radial loads from the aft cascade ring, and provide a mounting surface for it.

Hinge beam features are listed below.

- Hinge beam clevis (3)
- Thrust reverser alignment fitting
- Primary and auxiliary track sliders
- IFS doubler
- Ground bracket



THRUST REVERSER SYSTEM – HINGE BEAMS

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Latch Beams

Purpose:

Latch beams provide a structural connection between the IFS and transcowl.

Location:

The beams attach directly to the IFS and interface with the transcowl via the primary and auxiliary tracks integrated into the beams.

Description:

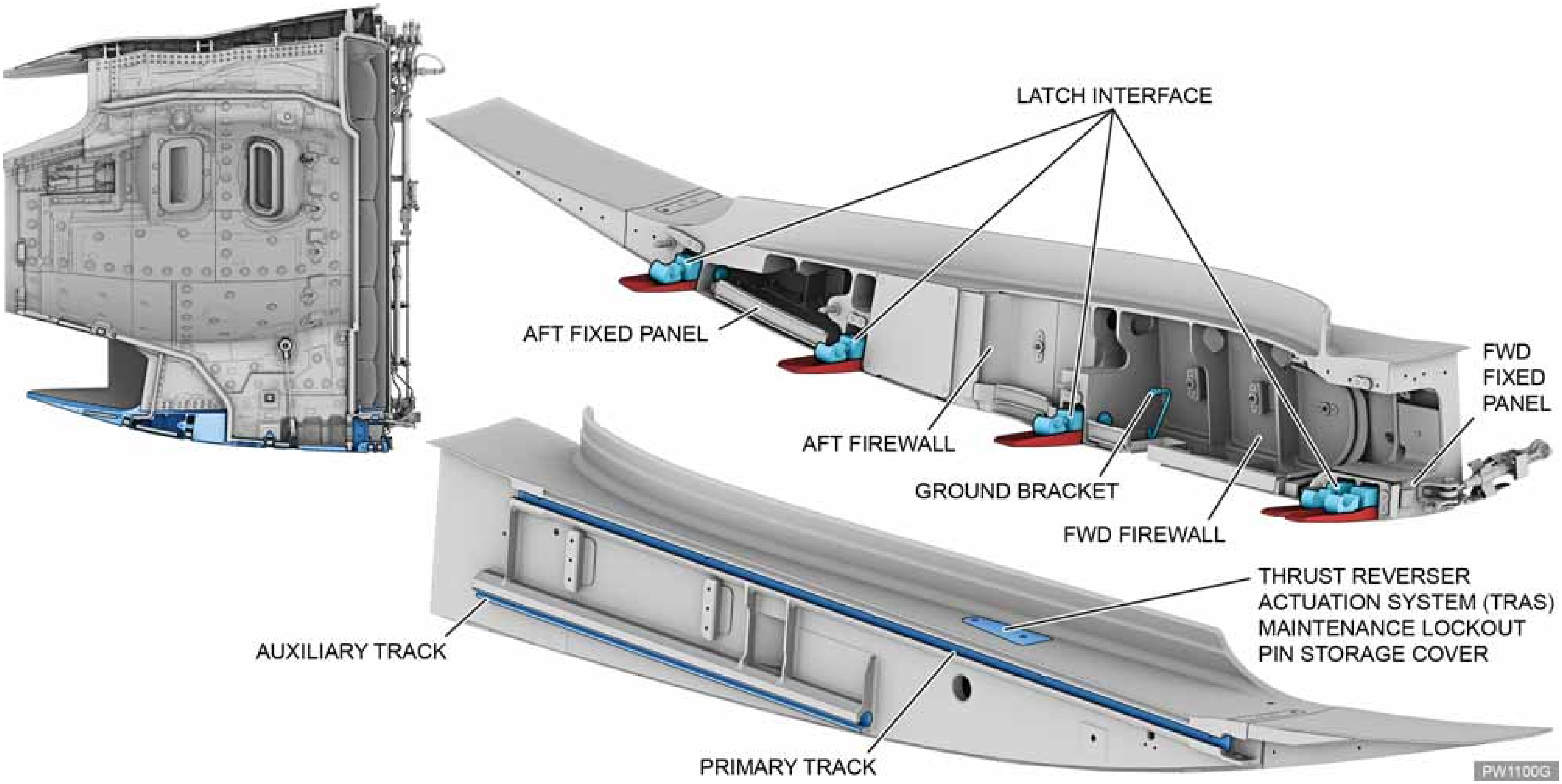
Latches are quick-release mechanisms integral to the latch beams and provide quick access to the engine core. The latches provide resistance to loads that might otherwise cause the thrust reverser to disengage or open during the flight cycle.

Five latches and a Bifurcation Latch System (BLS) are part of each latch beam. The aluminum beams feature integrated primary track and auxiliary track sliders that interface with the transcowl. They extend the length of the lower bifurcation, connect the two reverser halves via four latches, and serve as a mounting surface for the TRAS third lock.

Each latch beam incorporates mounting features for latch assemblies. The upper and lower surfaces of the latch beam represent the fan duct and nacelle outer surfaces, respectively.

Latch beam features are listed below.

- Latches and latch interface
- Primary and auxiliary track sliders for installation of the translating cowl
- Latch Access Panel (LAP)
- Forward and aft fixed panel and firewall
- Closure Assist Assembly (CAA)
- IFS attach Interface
- Stow pin or cover



THRUST REVERSER SYSTEM – LATCH BEAMS

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Latches

Purpose:

Latches integral to the beams provide structural hoop load transfer to the nacelle, and offer quick access to the engine core. The latches also provide resistance to loads that might otherwise cause the thrust reverser to disengage or open during the flight cycle.

Location:

The chart shows locations for all latches.

Description:

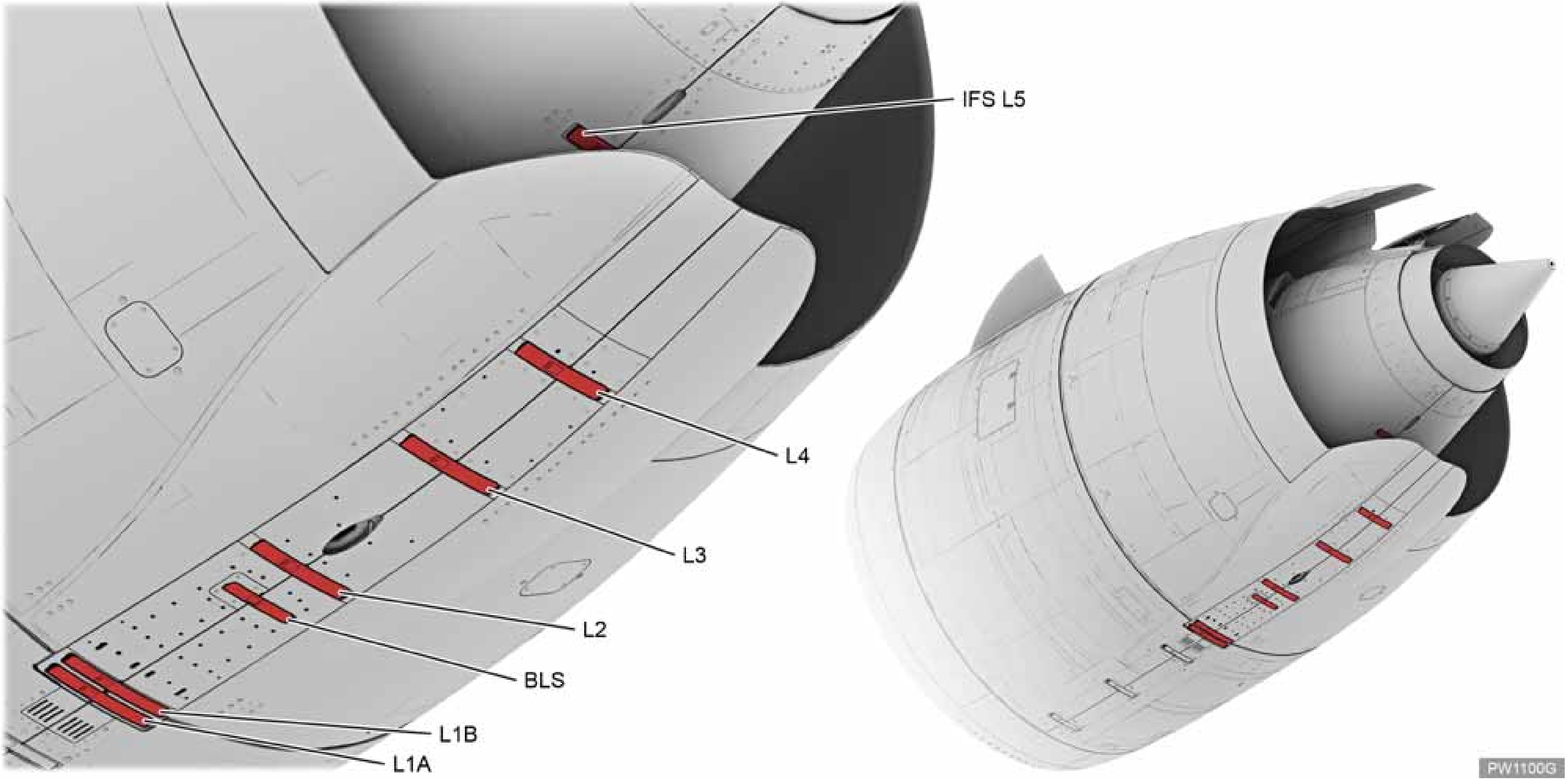
In the open position, the latch handles point downward to be visible in the event the thrust reverser doors are left unlatched after maintenance.

In addition to the latches, a Closure Assist Assembly helps close the cowling.

Operation:

To open the thrust reverser doors, the latches and BLS are opened in sequence. The sequence is reversed for closing the doors.

Latch	Location
L1A, L1B, BLS, L2	Forward fixed panel
L3, L4	Aft fixed panel
L5	IFS panel



THRUST REVERSER SYSTEM – LATCH BEAM LOCATIONS

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Closure Assist Assembly (CAA)

Purpose: LRU

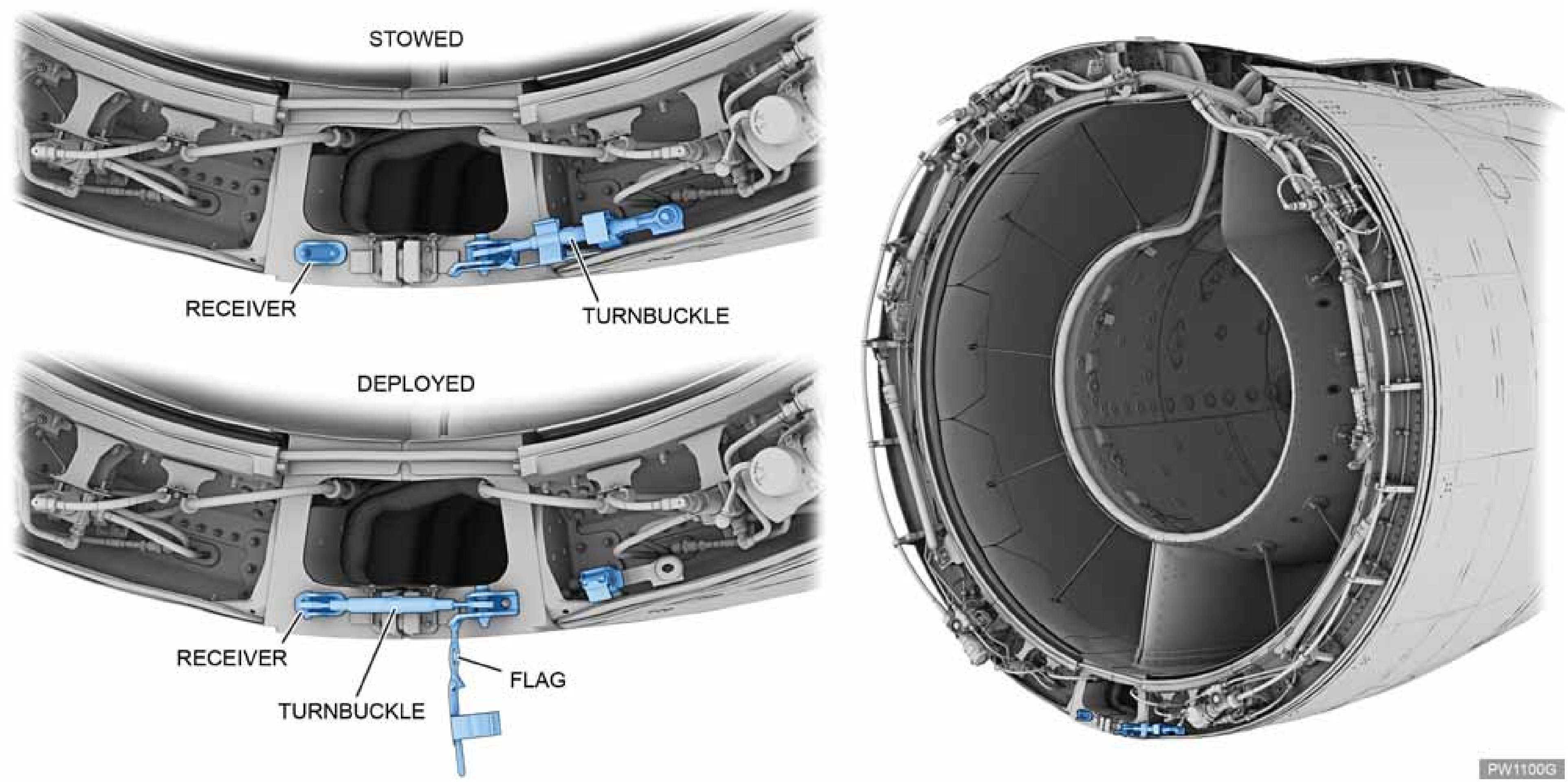
The Closure Assist Assembly consists of a turnbuckle that is used to draw the door together before engaging the latches.

Location:

The assembly is located on the front of the left thrust reverser at 6:00.

Description:

An eye on one end of the turnbuckle allows it to pivot so the pin engages the opposite cowling. Once engaged, the turnbuckle is turned manually to draw the two doors together. The turnbuckle is stowed after use.



THRUST REVERSER SYSTEM – CLOSURE ASSIST ASSEMBLY (CAA)

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Bumpers

Purpose:

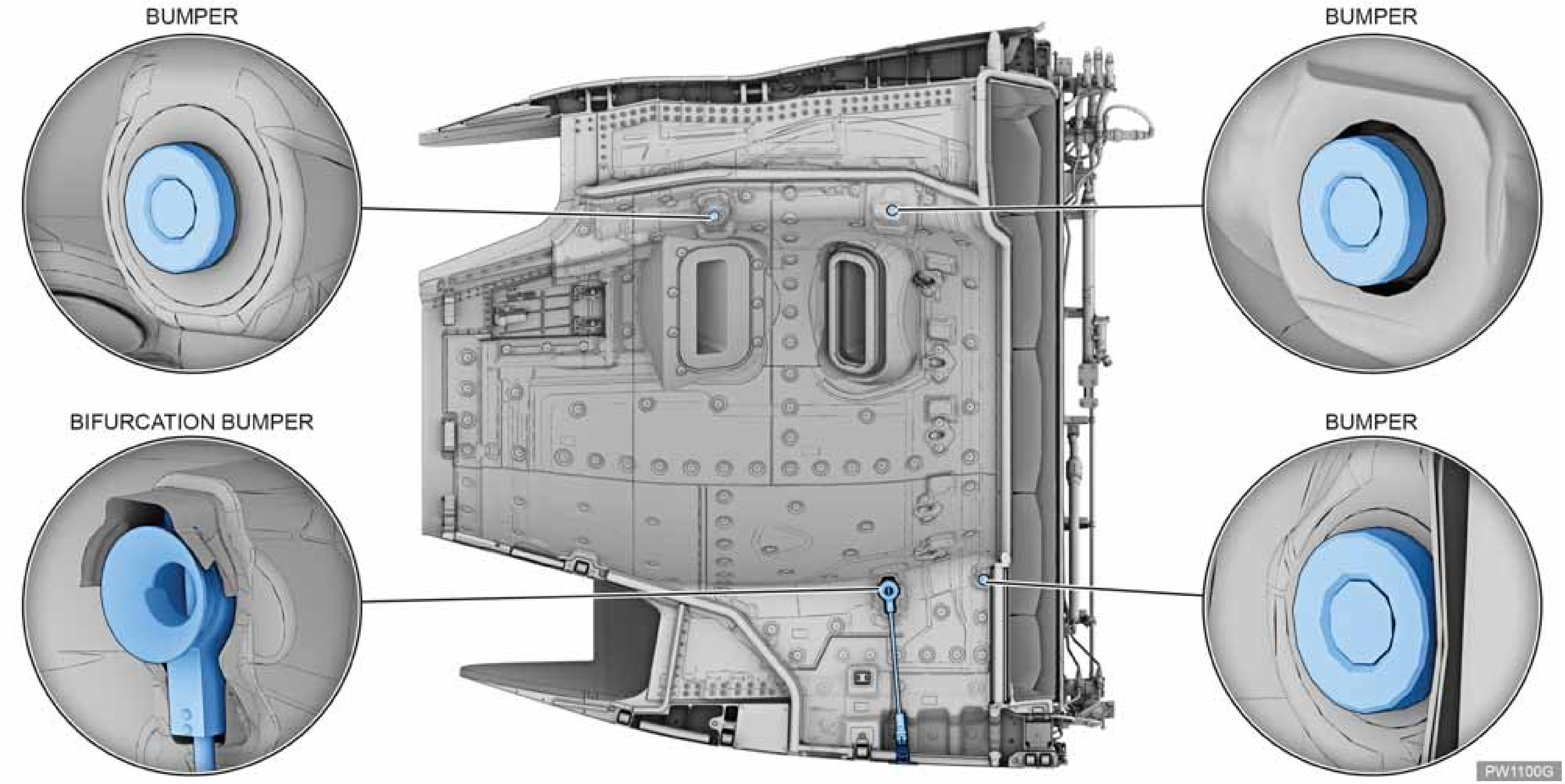
Bumpers provide a hoop load path to resist the crushing pressure of the fan air stream upon the barrel sections and bifurcations.

Location:

Three bumpers are located at the radius corner intersections between the thrust reverser barrel section and the bifurcation area.

Description:

Bumpers are aluminum components that act as deflection limiters to maintain a correct fit of the ducts to the engine, and to assist alignment as the two cowling halves are closed.



THRUST REVERSER SYSTEM – BUMPERS

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Bifurcation Latch System (BLS) LRU

Purpose:

The Bifurcation Latch System latches the two thrust reverser halves together and prevents gaps in the fire seals in the event of a burst duct..

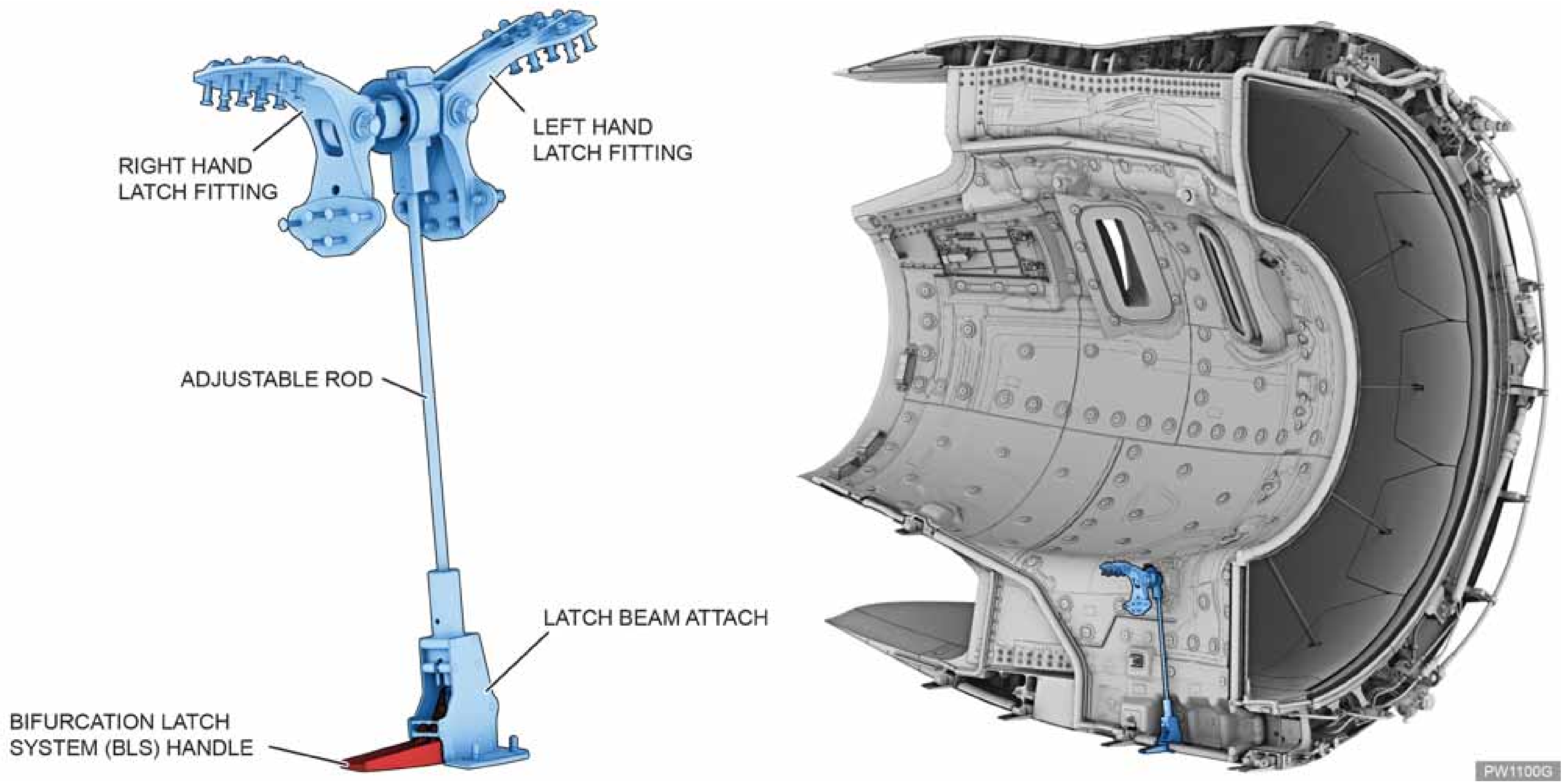
Location:

Left side thrust reverser IFS.

Description:

The BLS resembles the other bumpers but also incorporates a locking feature to keep it engaged. The BLS handle is accessed through the latch access door. The system is a pull-open, push-closed design with a baulking feature to visually indicate positive engagement of the latch. The latch is painted fluorescent orange so it will be visible when the latch is not closed.

The latch is adjustable to ensure proper engagement. When closed the handle remains parallel to the engine centerline.



THRUST REVERSER SYSTEM – BIFURCATION LATCH SYSTEM (BLS)

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS)

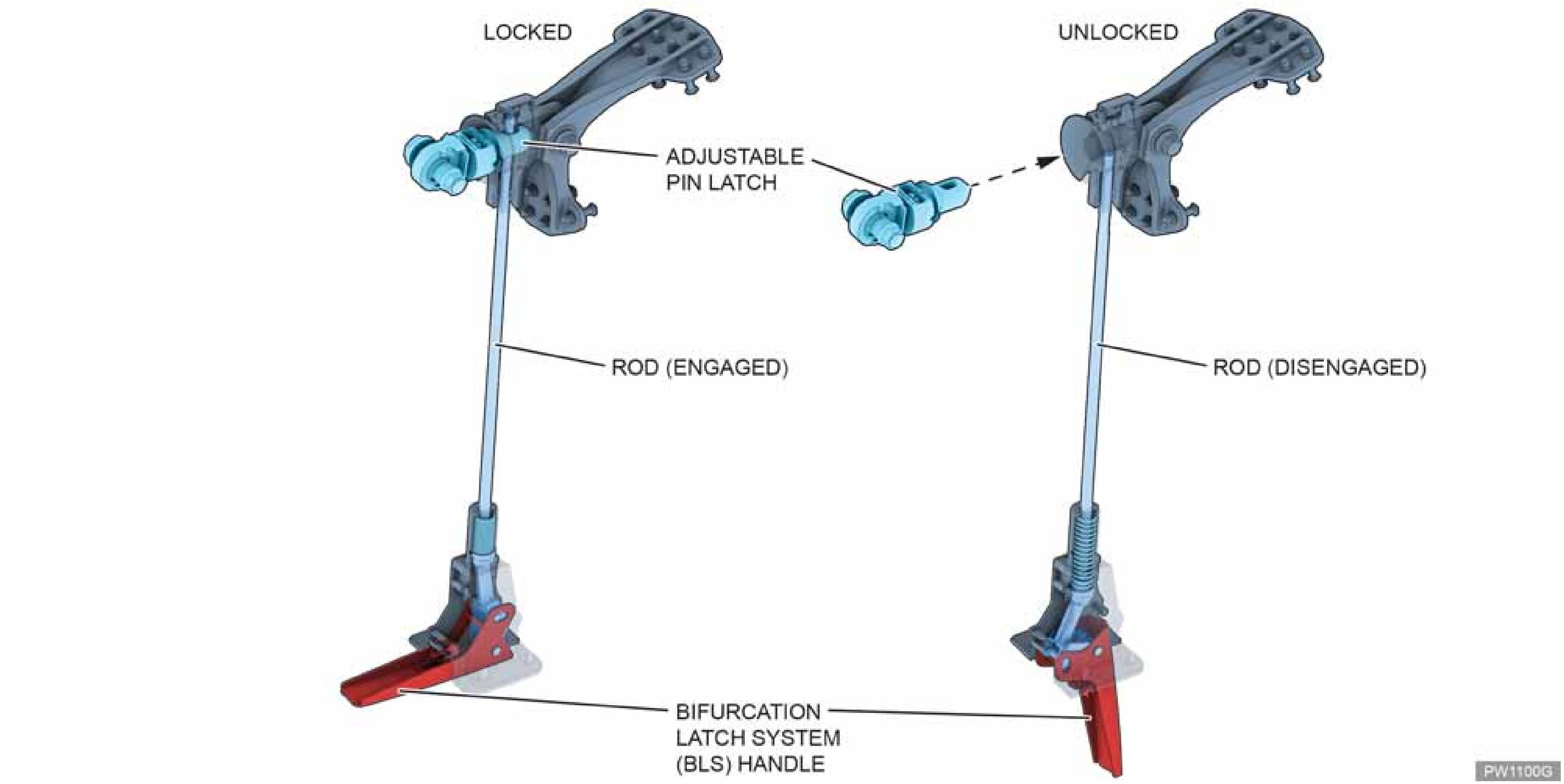
Bifurcation Latch System (BLS) (Cont.)

Operation:

When engaged, the bifurcation latch uses a rod and cam mechanism to insert a locking pin through the latch. As the IFS closes, a pin on the left side is inserted into a receiver located on the right side. The pin/latch mechanism is locked together using a rod. The rod is inserted through the pin by turning and pushing up the BLS handle.

The bifurcation latch is locked in place when the handle is aligned with the IFS by pushing the handle in. The pin latch mechanism is adjustable up to 0.635 cm (1/4 in.) in either direction.

The bifurcation handle is painted fluorescent orange, providing a visual indication of the position. In order for the bifurcation latch to properly engage, the handle should be positioned correctly.



THRUST REVERSER SYSTEM – BIFURCATION LATCH LOCKING

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Fire Seals

Purpose:

LRU

Fire seals provide fire protection and aerodynamic fit.

Location:

The seals are located circumferentially on the Inner Fixed Structure.

Description:

Fire protection consists of fireproof barriers and seal arrangements. The fire seals prevent the escape of flames from a fire zone and prevent air or fluids from entering. The seals are made of a soft, compressible fireproof material. The “turkey feather” barrier seal is made of metal.

Pressure Relief Door

Purpose:

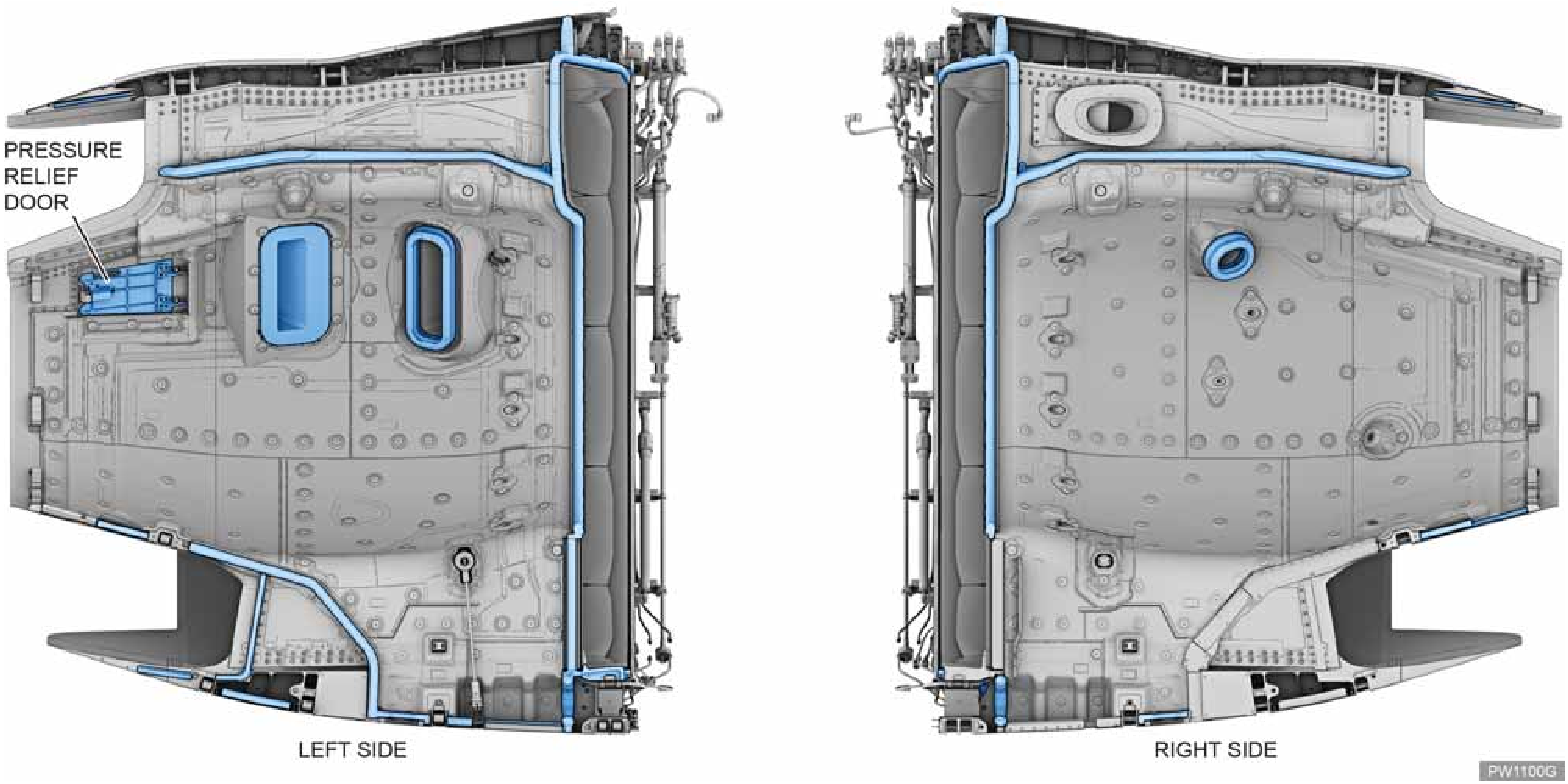
The pressure relief door provides adequate pressure relief when core cavity pressure exceeds the design limit.

Location:

The pressure relief door is on the left IFS at 9:00.

Description:

The door must open to provide adequate pressure relief when core cavity pressure goes above the designed cavity pressure. The pressure relief door opens if cavity pressure exceeds the latch release pressure, such as in the event of a burst cooling air duct.



THRUST REVERSER SYSTEM – FIRE SEALS AND PRESSURE RELIEF DOOR

THRUST REVERSER SYSTEM

Inner Fixed Structure (IFS) (Cont.)

Torque Box Assembly

Purpose:

The torque box is a curved beam with torsional stiffness that supports the thrust reverser actuators, cascades, hinge beam and latch beam.

Location:

The torque box runs from the hinge beam to the latch beam.

Description:

The torque box is composed of an aft bulkhead, conical ramp, bull nose fairing, segmented V-blade, a rub strip shim, and a fan cowl rub strip.

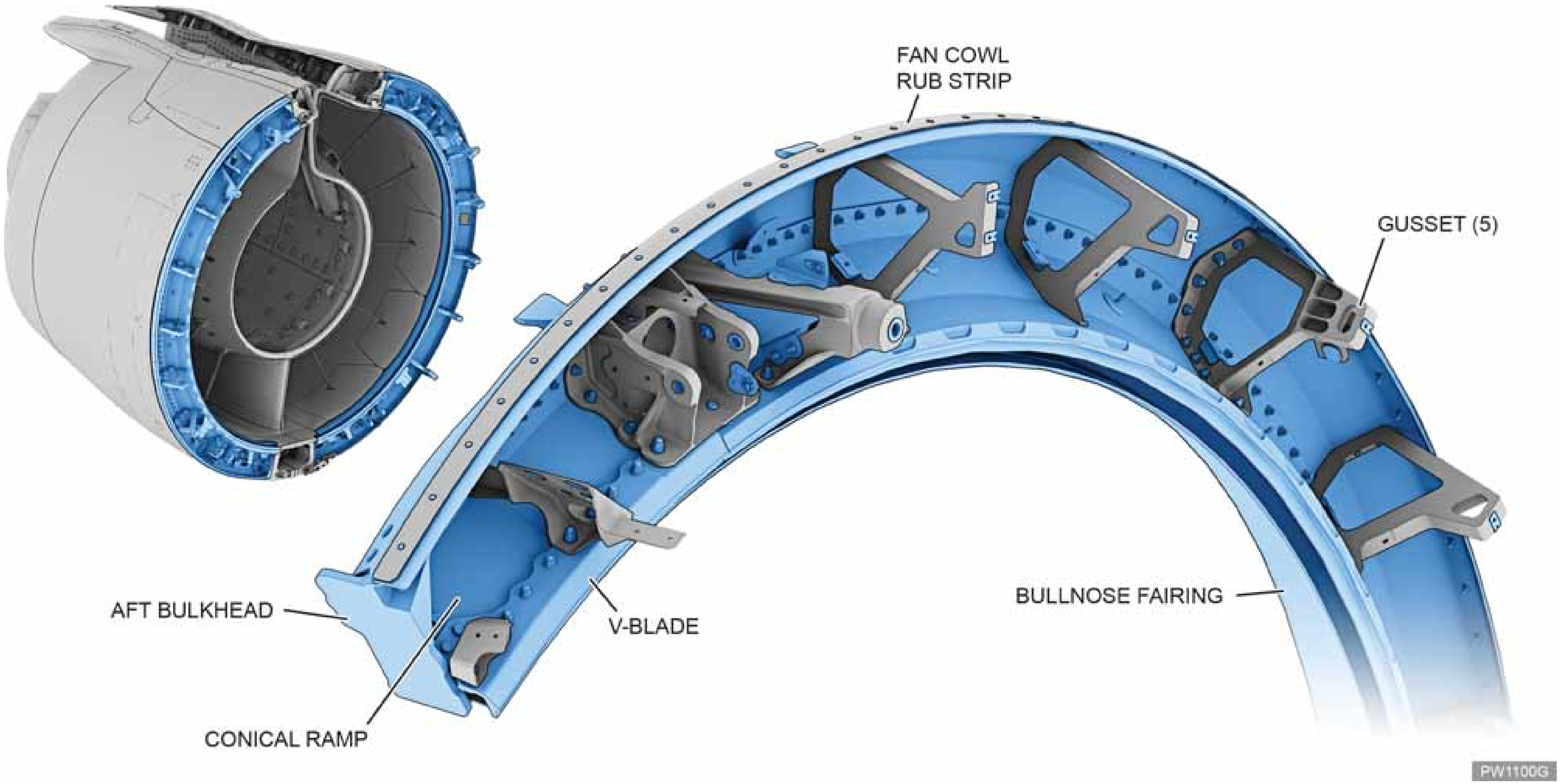
The conical ramp is the primary structural component of the torque box spanning from the engine V-groove to the aft bulkhead. The V-blade is attached to the conical ramp and directly interfaces with the engine V-groove, transferring loads from one to the other.

The forward bulkhead reacts to fan cowl and transcowl loads, transferring torque to the beams. The aft side of the conical ramp provides a mounting surface for the cascade boxes.

The torque box assembly provides a fire barrier to the nacelle and is manufactured out of composite aluminum extrusion, and titanium material.

Operation:

Torque from the actuators is transferred to the beams through the gussets. Loads from the Door Opening System (DOS) and Hold Open Rods (HORs) are transferred to the torque box through a DOS fitting and brackets attached to the bulkhead.



THRUST REVERSER SYSTEM – TORQUE BOX ASSEMBLY

THRUST REVERSER SYSTEM (Cont.)

Cascade Array

Purpose:

The cascade array turns fan airflow forward and sideways to reverse thrust and slow the aircraft.

Location:

Each cascade has a forward attachment at the torque box and an aft attachment at the Aft Cascade Ring (ACR).

Description:

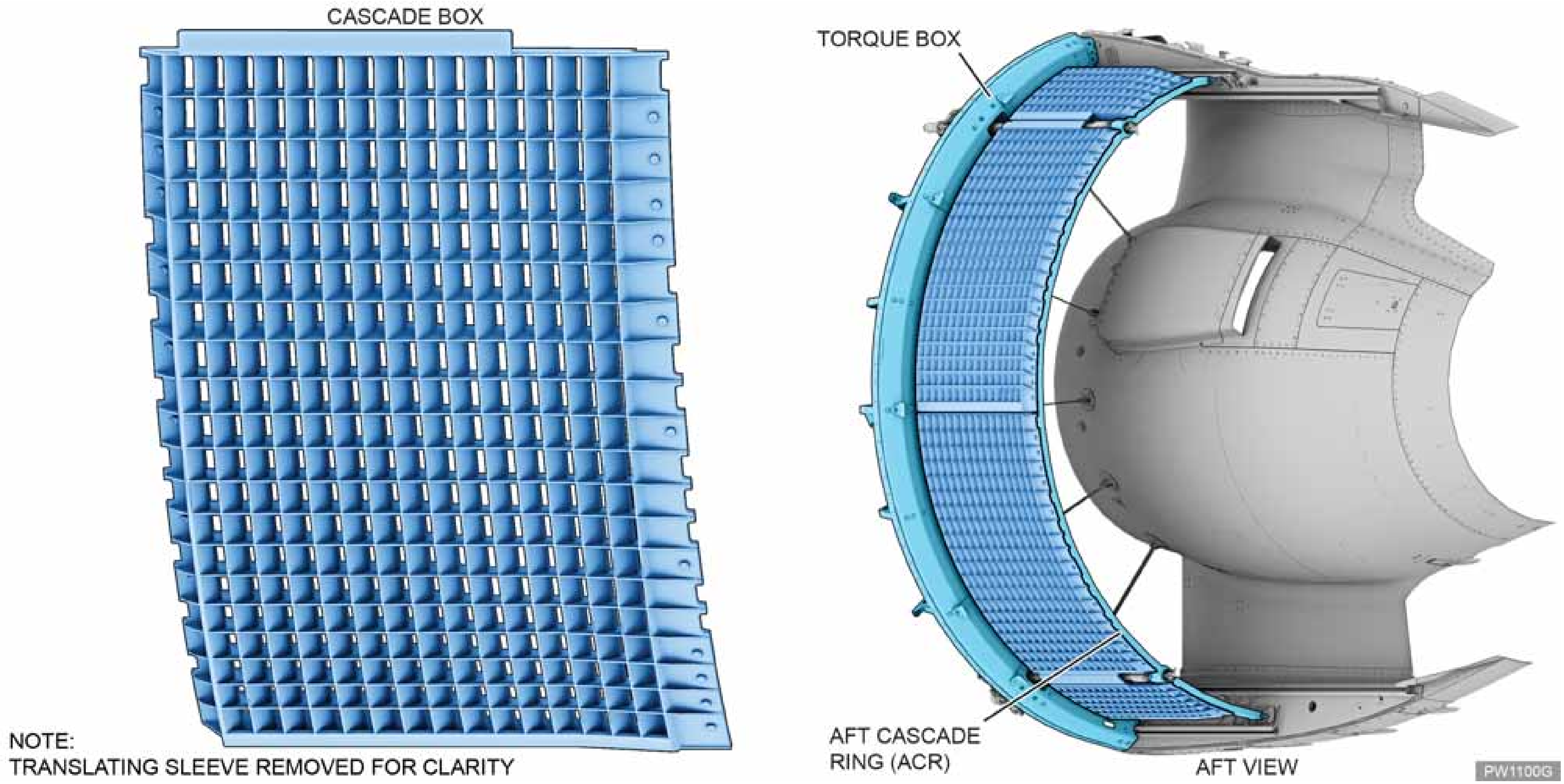
The fastener attachment pattern allows for limited interchangeability between cascade locations while ensuring the cascade cannot be installed backwards. Each engine has seven cascade boxes.

Operation:

Reverse thrust is achieved when the transcowl deploys the blocker doors and exposes an array of carbon-fiber composite cascade boxes. The forward-turning component of each cascade contributes to reverse thrust.

The combination of forward-turning and side-turning angles produces an efflux pattern that prevents these effects:

- reverse thrust airflow re-ingestion into the inlet
- cross engine inlet re-ingestion
- fuselage impingement
- impingement on the aircraft's control surfaces.



THRUST REVERSER SYSTEM – CASCADE ARRAY

THRUST REVERSER SYSTEM (Cont.)

Aft Cascade Ring (ACR)

Purpose:

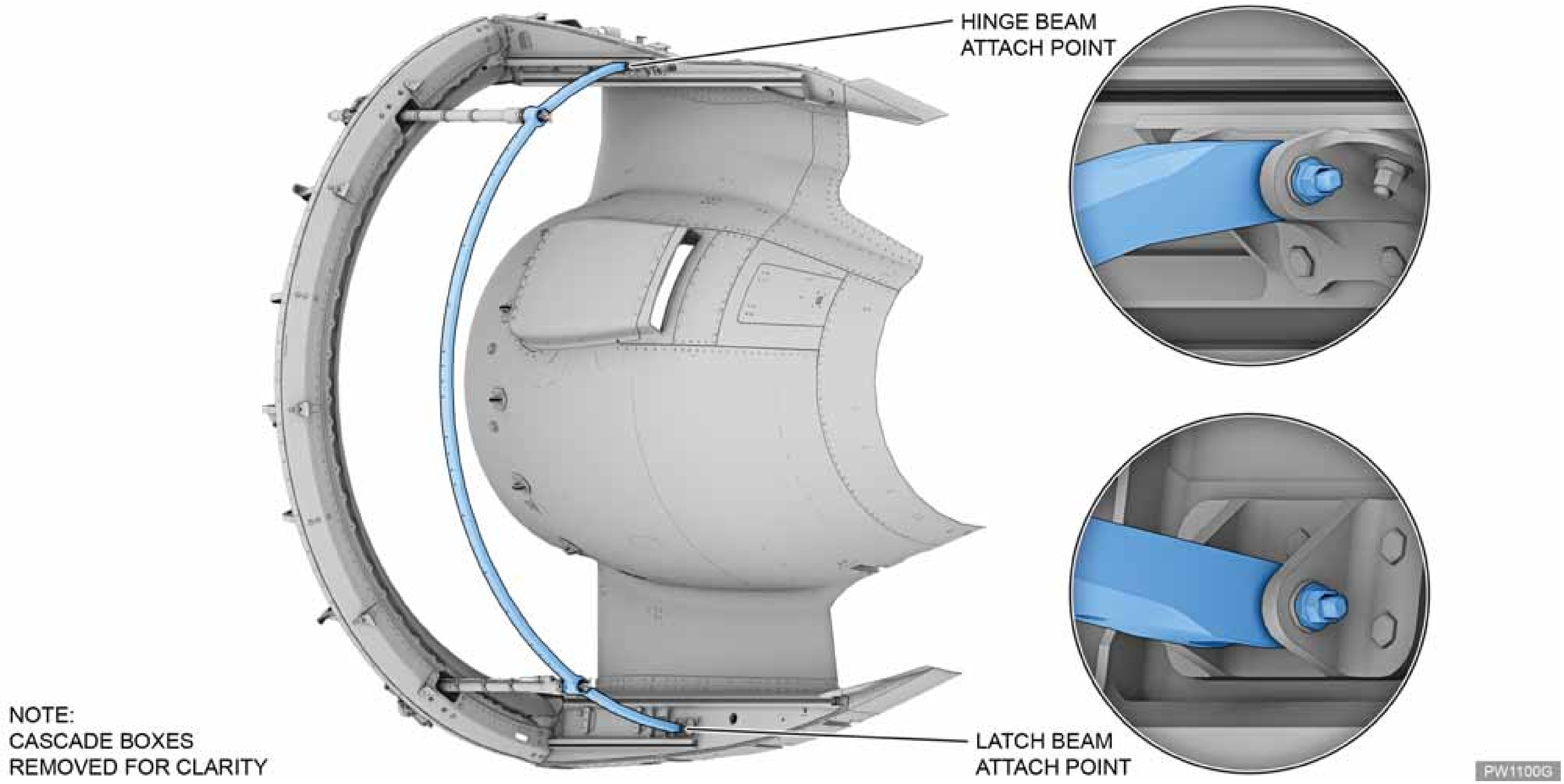
The Aft Cascade Ring provides aft support for the cascade segments.

Location:

The ACR beam runs from the hinge beam to the latch beam along the aft edge of the cascades.

Description:

The ACR is a curved, open-section metal beam that transmits aerodynamic and dynamic loads from the cascades to the hinge and latch beams.



THRUST REVERSER SYSTEM – AFT CASCADE RING

THRUST REVERSER SYSTEM (Cont.)

Hold Open Rods (HORs)

Purpose:

LRU

HORs prop open the thrust reverser to provide a safe environment for performing maintenance work on the engine.

Location:

HORs are attached to the thrust reverser torque box and the engine's fan case.

Description:

Each thrust reverser has one Hold Open Rod. Hold Open Rods are stowed on the torque box when not in use.

Operation:

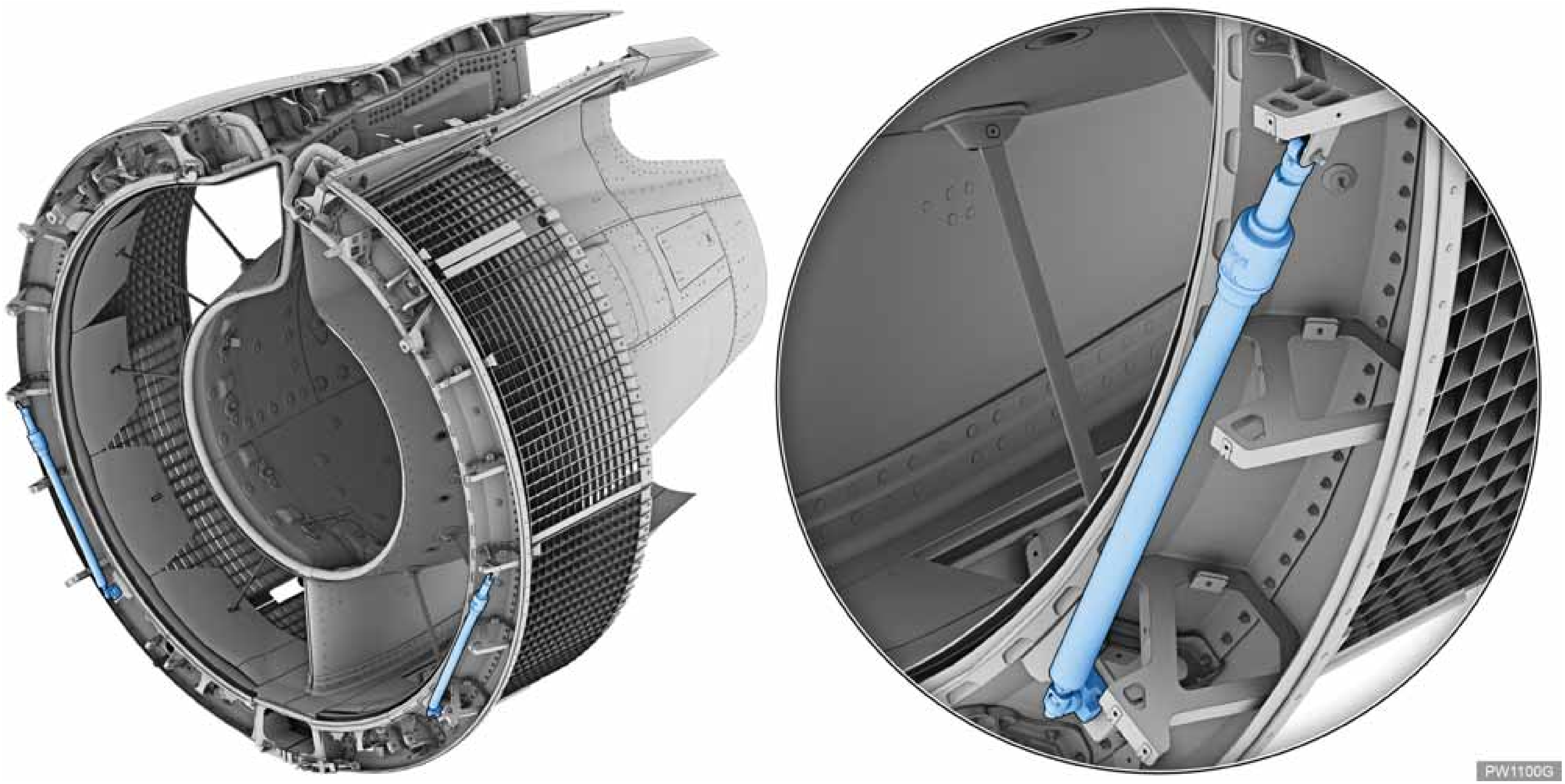
Each HOR functions to support the Thrust Reverser when in the open position. A swivel end on the HOR is installed on the torque box. When the Thrust Reverser is opened, the HOR is disengaged from the stowed position and extended to allow the rod hook to be engaged into to the Fan Case fitting and locked in place.

Safety Conditions

WARNING

HAVE A PERSON HOLD OPEN THE FAN COWL DOOR TO MAKE SURE IT DOES NOT FALL. THE FAN COWL DOOR WEIGHS MORE THAN 62.14 LB (28.19 KG). IF THE DOOR FALLS, IT CAN CAUSE INJURY AND/OR DAMAGE TO THE ENGINE.

MAKE SURE THE QUICK RELEASE PINS ARE LOCKED INTO PLACE AND INSTALLED CORRECTLY BEFORE YOU LOWER THE FAN COWL DOOR. THE FAN COWL DOOR WEIGHS MORE THAN 62.14 LB (28.19 KG). INJURY AND/OR DAMAGE TO THE ENGINE CAN OCCUR IF THE DOOR FALLS.



THRUST REVERSER SYSTEM – HOLD OPEN RODS (HORs)

THRUST REVERSER SYSTEM (Cont.)

Thrust Reverser Actuation System (TRAS)

The Thrust Reverser Actuation System (TRAS) controls deployment, stowing, locking, and holding of the thrust reverser in response to signals generated by the aircraft and engine.

The thrust reverser is made up of two halves that are mechanically decoupled, and which hinge from the pylon. The halves latch together along the bottom split line. Upon deployment, translating sleeves move aft, causing blocker doors to rotate and block the fan air. This action redirects the fan flow through the thrust reverser cascades, sending air forward and outward in a controlled plume and providing reverse thrust.

A Hydraulic Control Unit (HCU) provides isolation and directional control of hydraulic fluid used for thrust reverser actuation. Two hydraulic linear synchronized actuators per side deploy and stow the reverser. The thrust reverser can be used for either engine position as long as the cascade pattern is changed to match airflow control requirements.

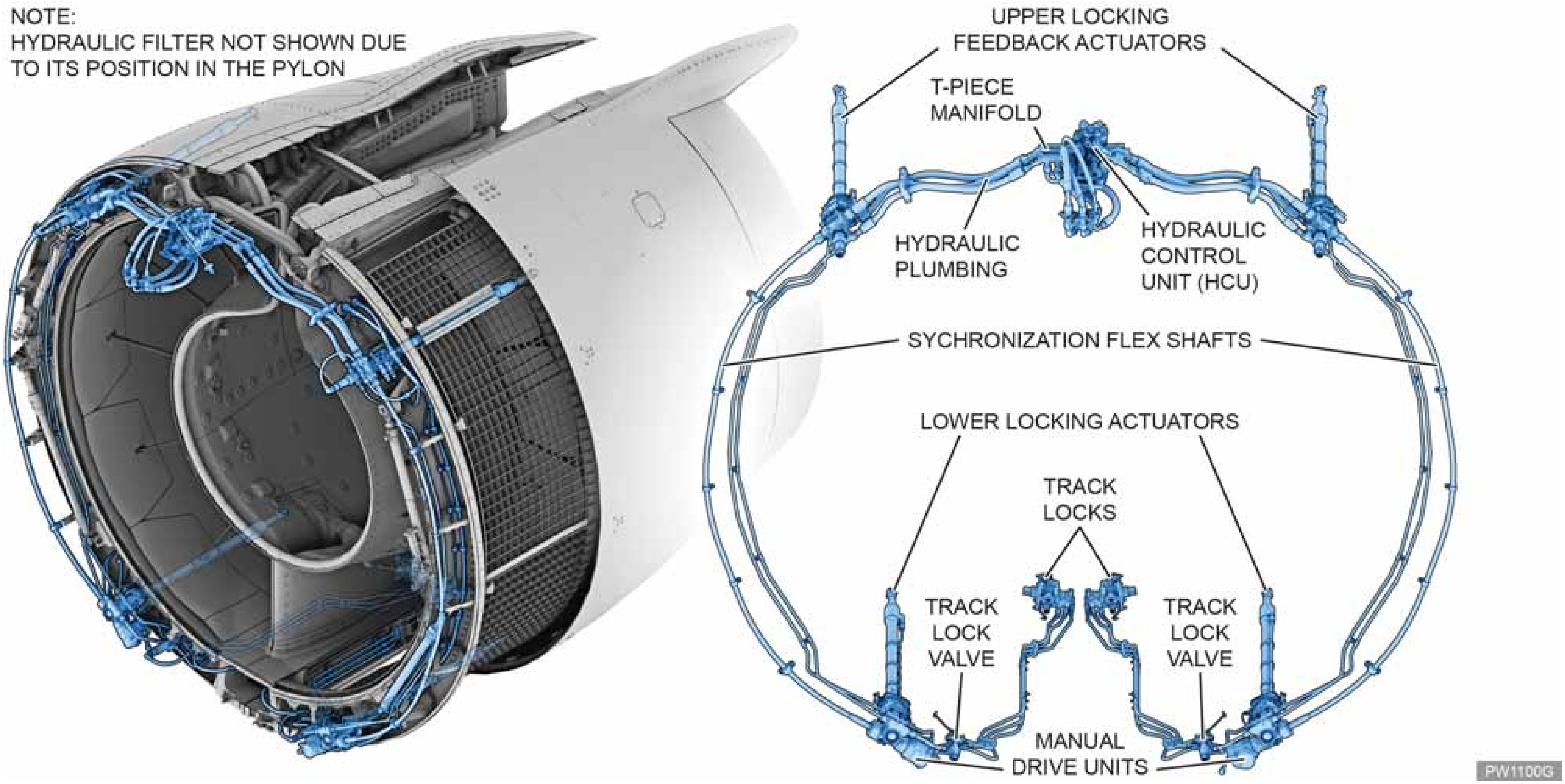
Each half of the thrust reverser has two actuator units that include an integral locking mechanism and proximity sensor, and one actuator with a Linear Variable Differential Transformer (LVDT) for reverser position feedback.

The thrust reverser also includes a “third line of defense” provided by two fully independent track locks.

Reversers can be deployed and stowed manually on the ground by using the Manual Drive Units (MDUs) located on the lower actuators.

Components for this system are listed below.

- Hydraulic Control Unit HCU
- Filter module assembly
- T-piece manifold
- Locking actuator (2)
- Locking feedback actuator (2)
- Manual Drive Unit (2) MDU
- Synchronization flexshaft (2)
- Track lock valve (2)
- Track lock (2)
- Wiring harness and plumbing up to pylon interfaces



THRUST REVERSER ACTUATION SYSTEM (TRAS) COMPONENTS

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Hydraulic Control Unit LRU PMT

Purpose:

The Hydraulic Control Unit (HCU) controls the locking, unlocking and translating operation of the actuators.

Location:

The HCU is located in the pylon upper spar.

Description:

The HCU contains the Isolation Control Valve (ICV) and the Directional Control Valve (DCV), and their respective solenoids.

The ICV and DCV are operated from dual channel solenoid pilot valves upon a signal from the EEC.

A manual inhibition function provides these capabilities:

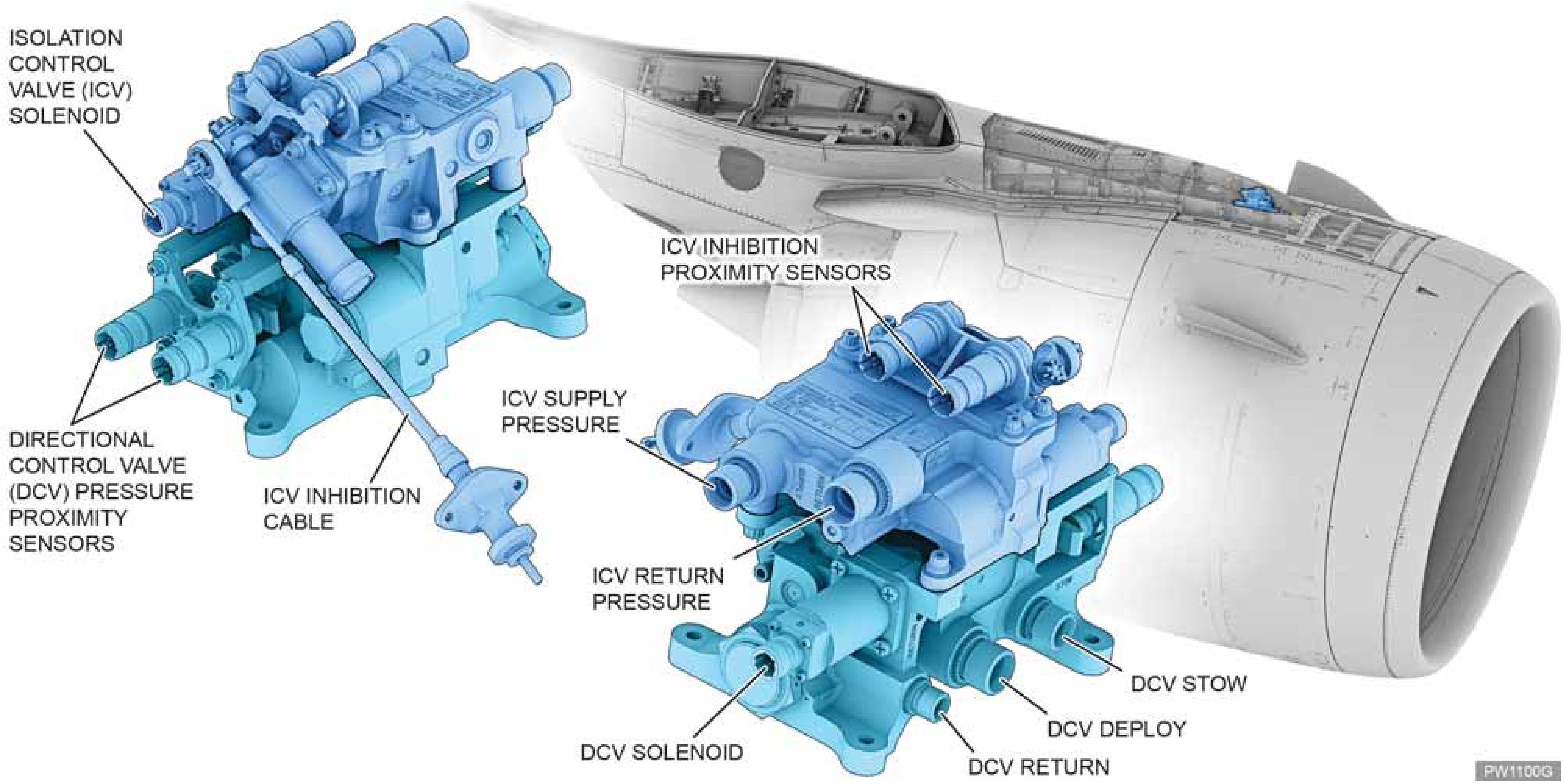
- dispatches inoperative thrust reversers
- prevents inadvertent activation of the ICV
- provides additional safety during ground maintenance activities.

Deactivation is provided by an inhibit lever and inhibit pin. Proximity sensors detect the lever's position.

Operation:

The ICV isolates the entire downstream system from the aircraft hydraulic pressure supply, unless an arming signal is received. Hydraulic fluid to power the TRAS is supplied from the aircraft system.

The DCV uses a spool valve to regulate the direction of pressure application to the actuators in order to achieve the unlock, deploy, stow and relock sequence. The DCV position signal comes from proximity sensors.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – HYDRAULIC CONTROL UNIT (HCU)

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Filter Module Assembly LRU PMT

Purpose:

The filter module assembly protects downstream TRAS components from debris that may be present in the aircraft hydraulic system.

Location:

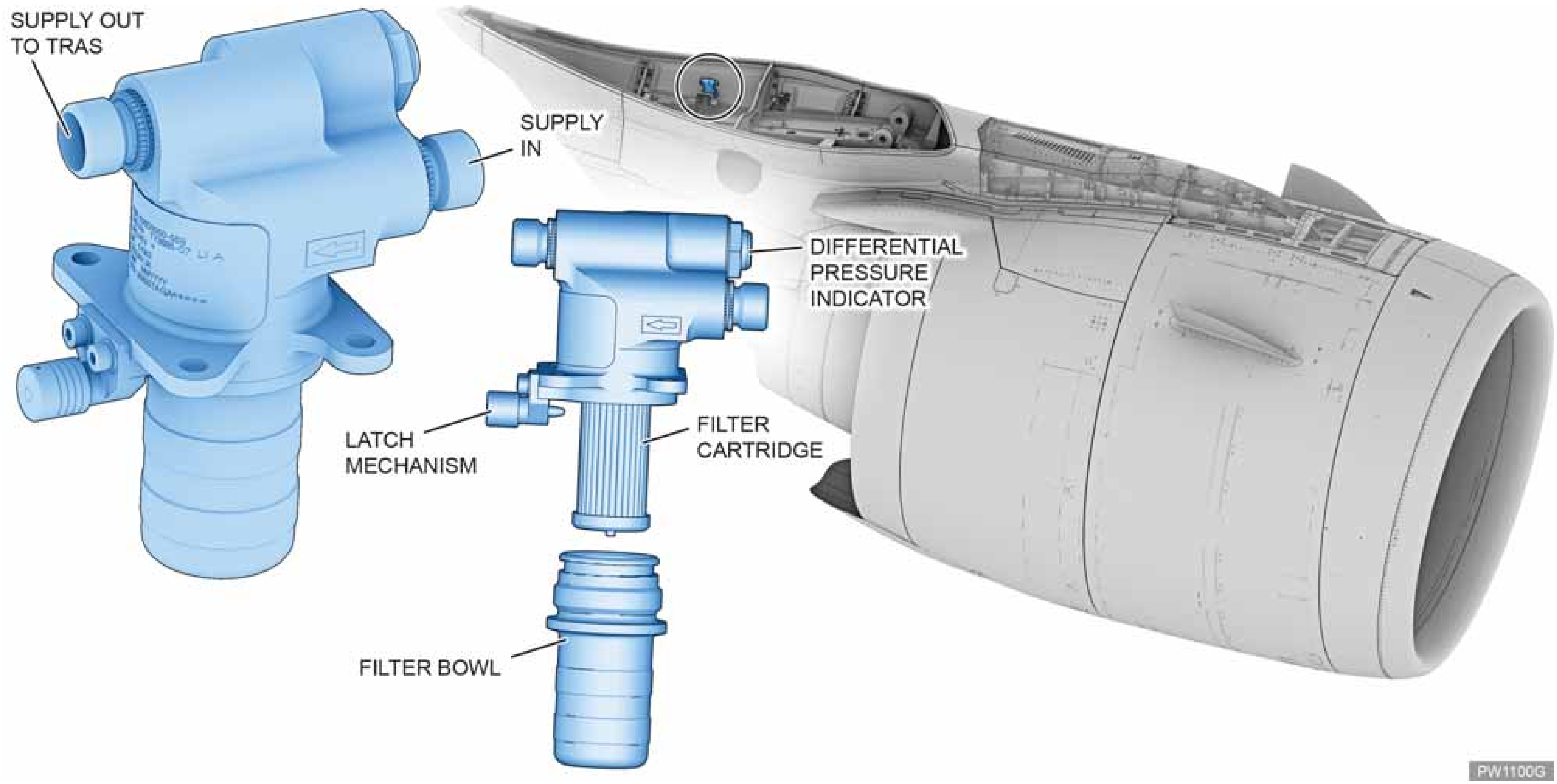
The assembly is mounted in the pylon above the lower aft pylon fairing.

Description:

The 15-micron filtration system is installed on the inlet side of the thrust reverser supply. An automatic shutoff valve allows removal and installation of the filter without significant loss of hydraulic fluid from the system.

In this instance, the system will still function but will be slow to deploy or stow.

A differential pressure indicator, or “red button,” pops out to visually indicate when the filter is clogged.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – FILTER MODULE ASSEMBLY

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

T-piece Manifold

Purpose:

The T-piece manifold provides a path for hydraulic system pressure to be ported from the Directional Control Valve (DCV) to the TRAS locking actuators.

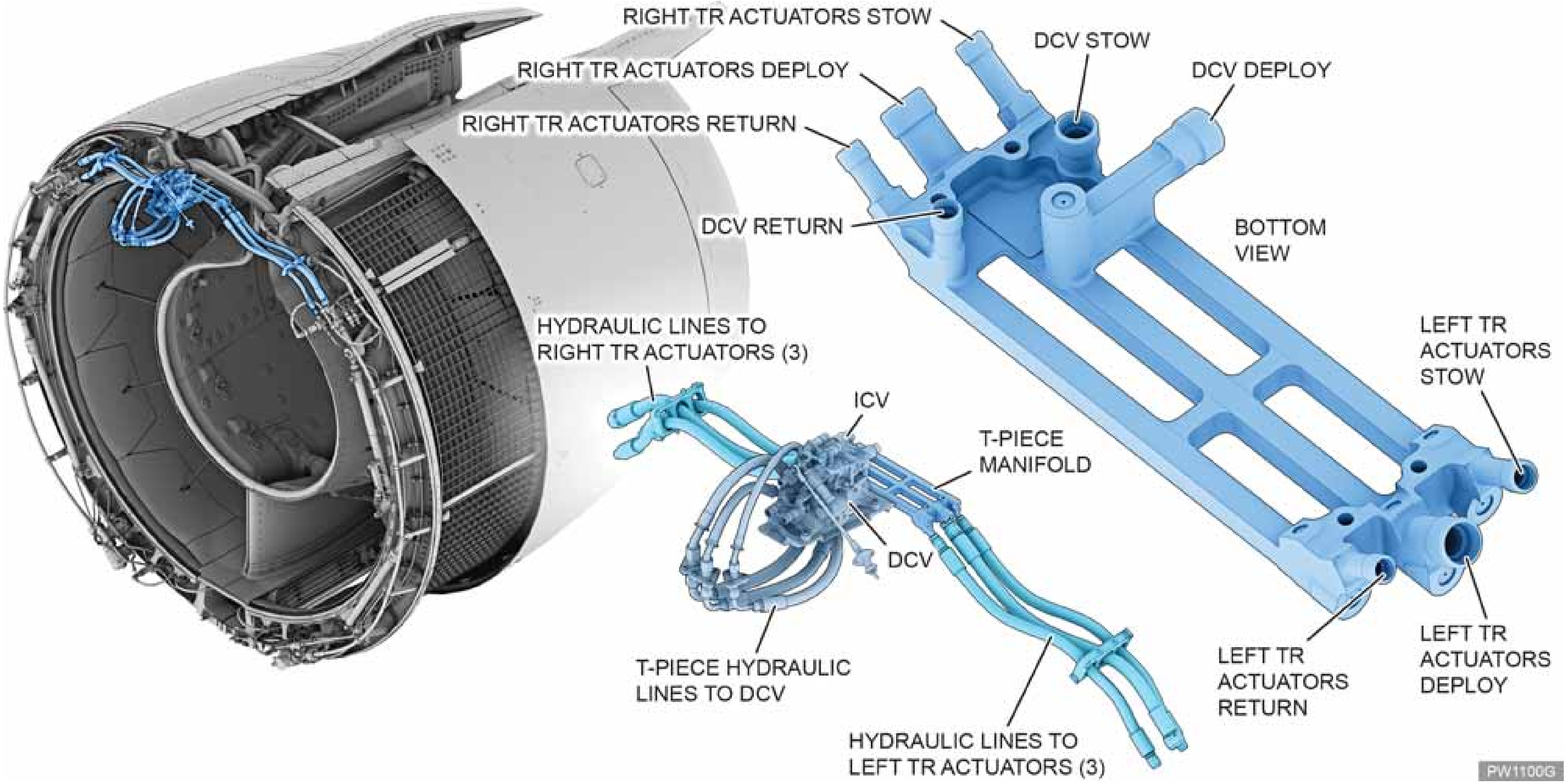
Location:

The manifold is located in the forward section of the pylon.

Description:

Three hydraulic lines connect the Hydraulic Control Unit (HCU) to the T-piece manifold. The T-piece manifold splits each line, so each thrust reverser door has a deploy, stow, and return line.

The Directional Control Valve is part of the HCU. The DCV sends hydraulic fluid to the actuators to either deploy or stow, depending on whether the thrust reverser is opening or closing. The fluid then travels back to the DCV via the return line.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – T-PIECE MANIFOLD

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Lower Locking Actuator LRU PMT

Purpose:

The actuators deploy and stow the reverser sleeves and also lock them in the stowed position.

Location:

The actuators are mounted on the thrust reverser torque box at approximately 5:00 and 7:00.

Description:

The movement of the lower locking actuators is synchronized with the motion of the upper locking actuators using a synchronization flexshaft.

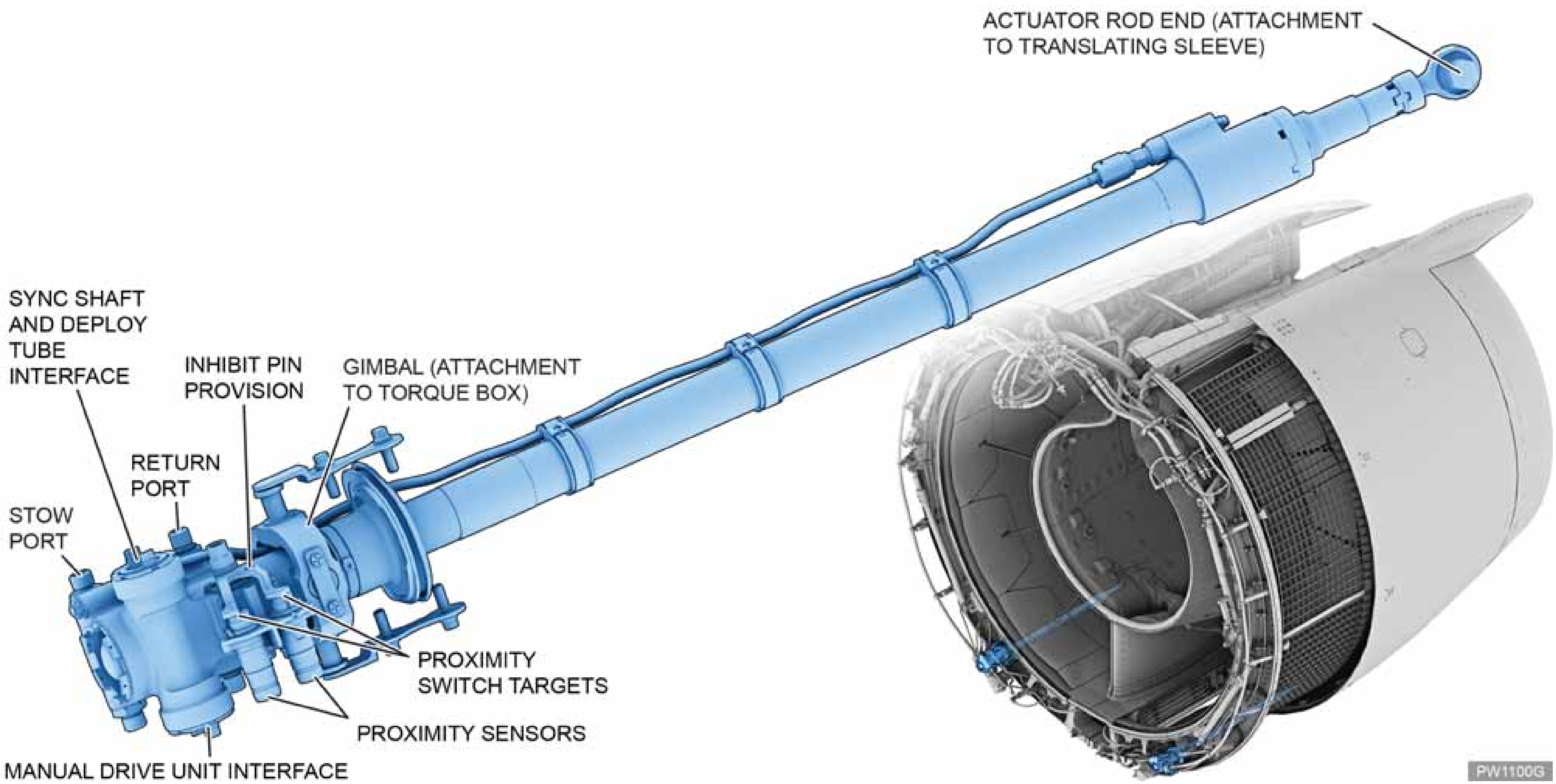
The lower actuators each incorporate an integral, hydraulically released mechanical locking element. A manual lock release provision facilitates manual translation of the reverser via manual drive units located on each side. Lock release and manual drive access is gained by opening the fan cowl doors.

An inhibit handle is provided to lock out the actuator during maintenance with the Manual Drive Unit (MDU). A gimbal allows for thrust and torsional motion of the actuator during operation. Lock release and manual drive access is gained by opening the fan cowl doors.

A proximity sensor is included in the locking mechanism of each actuator to provide the electrical feedback of lock engagement status to the EEC.

Operation:

The actuators are operated hydraulically using worm wheels and flex drive shafts. When the command is given by the crew through the movement of the throttle levers, and when additional conditions are met, the reverser deploys and stows.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – LOCKING ACTUATOR

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Upper Locking Feedback Actuator LRU PMT

Purpose:

The actuators are used to deploy and stow the reverser sleeves, lock them in the stowed position, and provide feedback of sleeve position.

Location:

The actuators are mounted on the thrust reverser torque box at approximately 1:00 and 11:00.

Description:

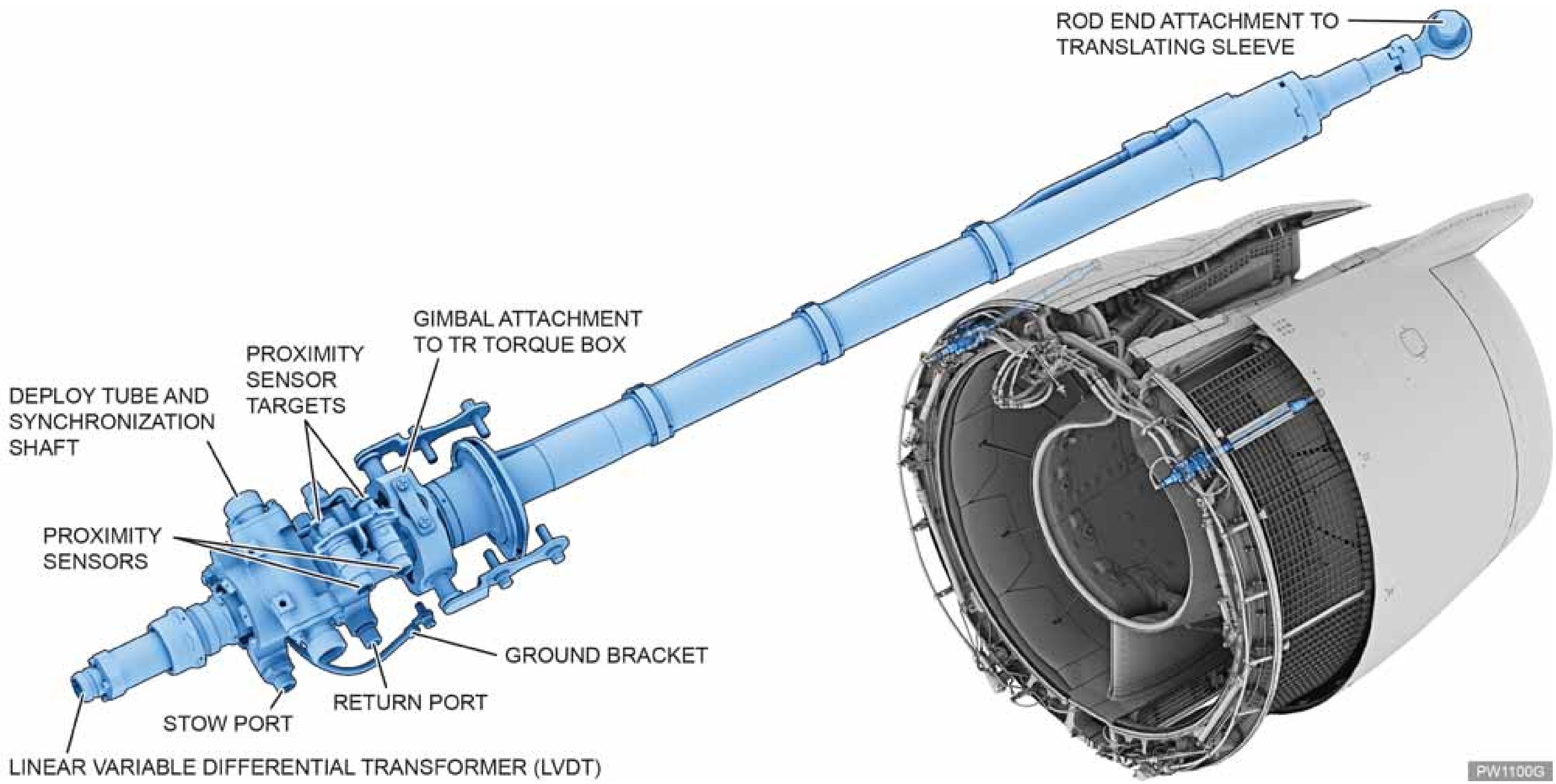
The actuators each incorporate and integral, hydraulically released mechanical locking element. A proximity sensor switch is included in the locking mechanism of the actuator to provide the electrical feedback of lock engagement status to the EEC. The proximity sensor requires no rigging. Electrical feedback of thrust reverser position is accomplished by means of an LVDT integrated into each upper actuator.

An inhibition handle is provided to lock out the actuator during maintenance so that manual translation of the reverser via Manual Drive Units (MDUs) can be accomplished. A gimbal allows for thrust and torsional motion of the actuator during operation.

Operation:

The actuators are operated hydraulically using aircraft hydraulics, worm wheels and flex drive shafts. When the command is given by the crew through the movement of the throttle levers, and when additional conditions are met, the reverser deploys and stows via the mechanical coupling between the upper and lower actuators.

A single-channel LVDT device on each upper actuator can provide true dual channel thrust reverser position feedback to the EEC.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – LOCKING FEEDBACK ACTUATOR

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Manual Drive Units (MDUs) LRU PMT

Purpose:

Manual drive units allow manual translation of the thrust reverser during maintenance.

Location:

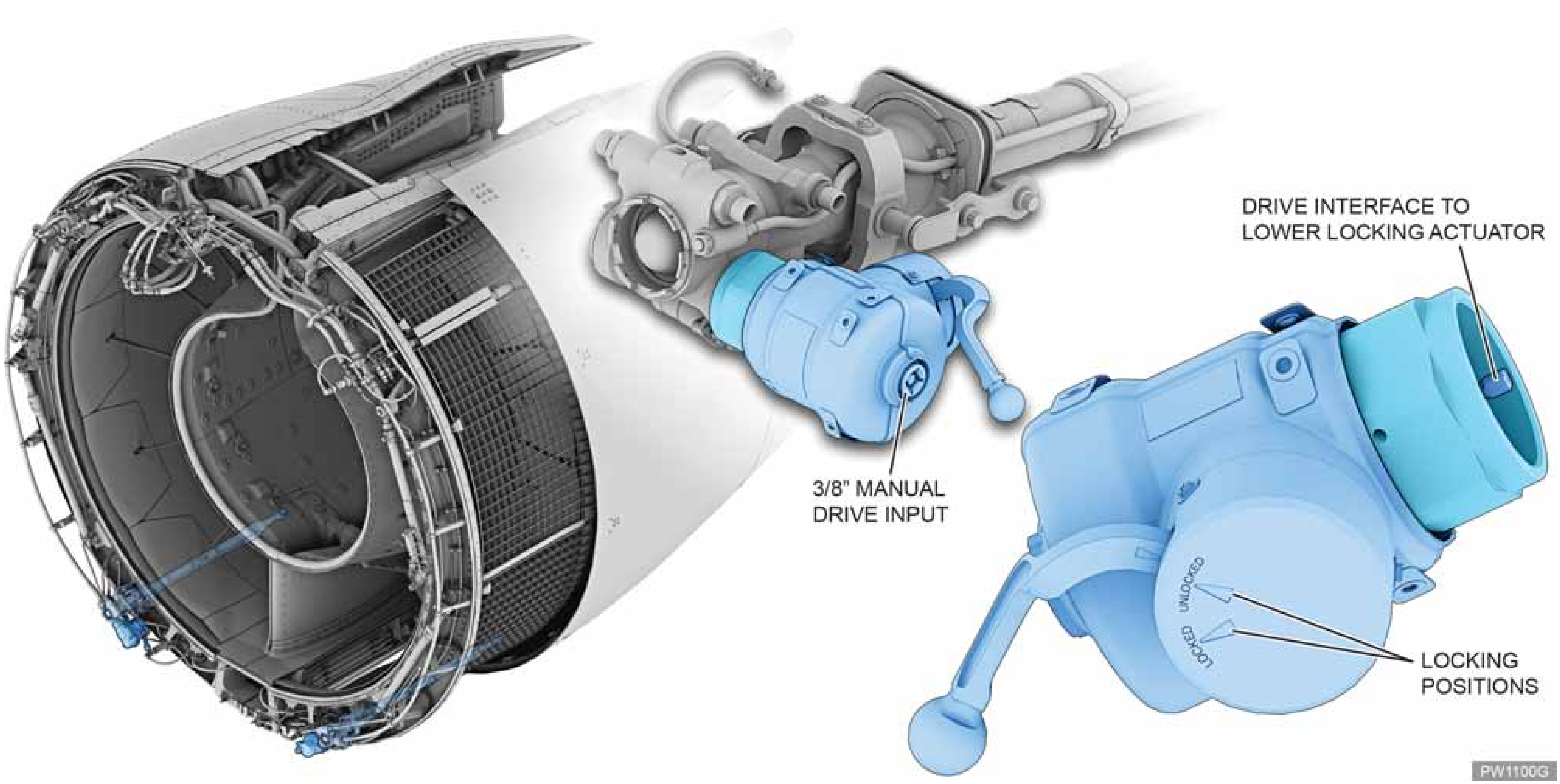
Each of the two MDUs is mounted to one of the locking actuators.

Description:

MDUs are only used when aircraft is in maintenance configuration. The maximum operational speed for an MDU is 600 rpm.

Operation:

A $^{3}/_{8}$-in. square-drive tool input enables manual rotation of the TRAS synchronization system and translates the sleeve as required. A clutch torque limiter in each MDU, which provides over torque protection, is installed to prevent damage to TRAS components during TRAS manual operation. A baulking feature on the fan cowl pushes the lock lever to the locked position in the event an MDU lock lever is left unlocked.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – MANUAL DRIVE UNIT

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Synchronization Flexshafts LRU PMT

Purpose:

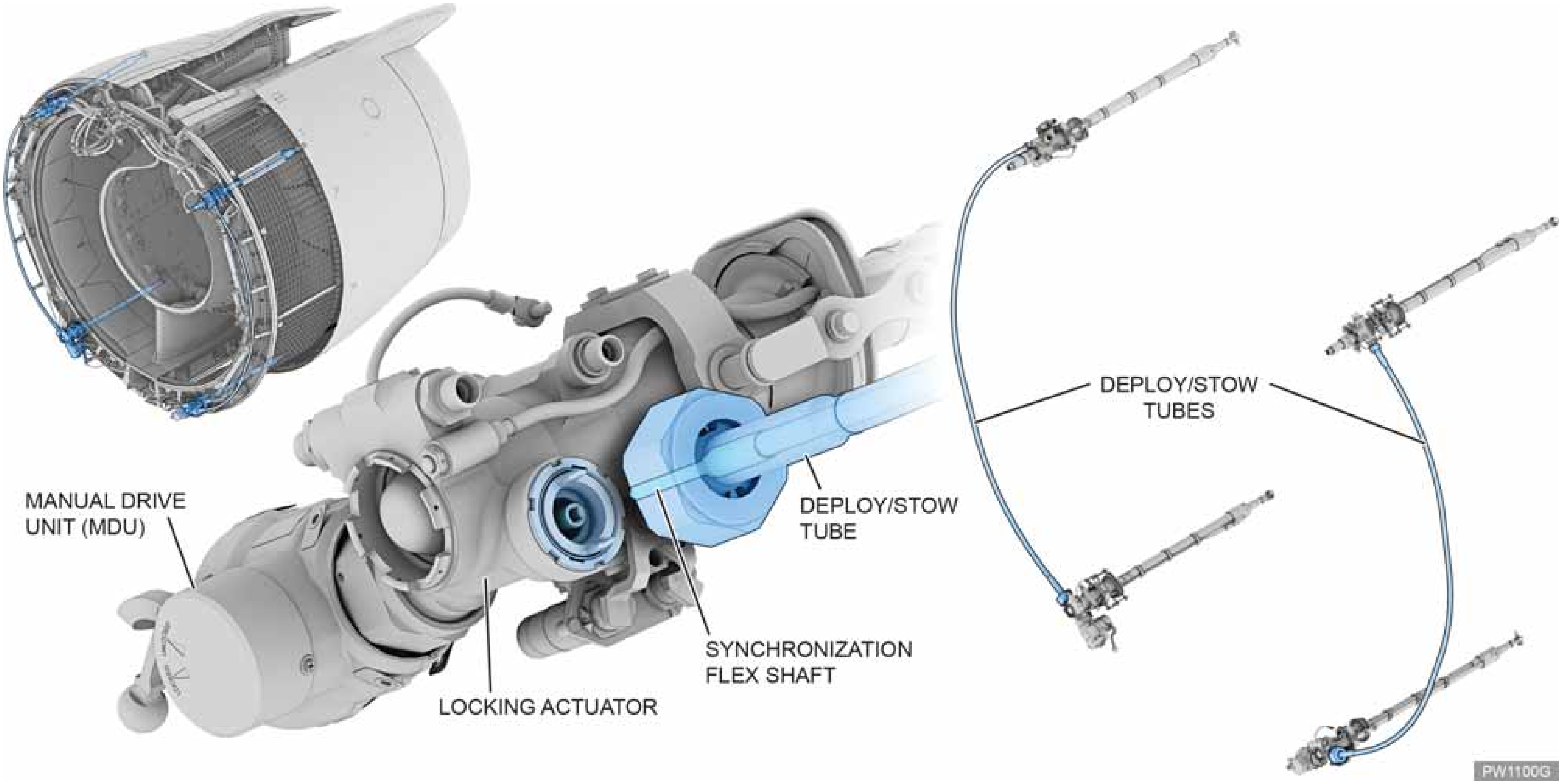
Flexshafts provide TRAS synchronization by connecting the upper locking feedback actuator to the lower locking actuator on each thrust reverser half.

Location:

The synchronization shafts are located inside the deploy tubes which are mounted to the thrust reverser torque box.

Description:

Each cowl half has one flexshaft. The deploy tube provides a path for the TRAS hydraulic system to pressurize during deploy and stow sequence. The flexshaft square drive interfaces with the actuator drive system and is secured by the deploy tube to the actuator.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – SYNCHRONIZATION FLEXSHAFTS

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Track Lock Valves LRU PMT

Purpose:

Track lock valves control the locking and unlocking of the track locks.

Location:

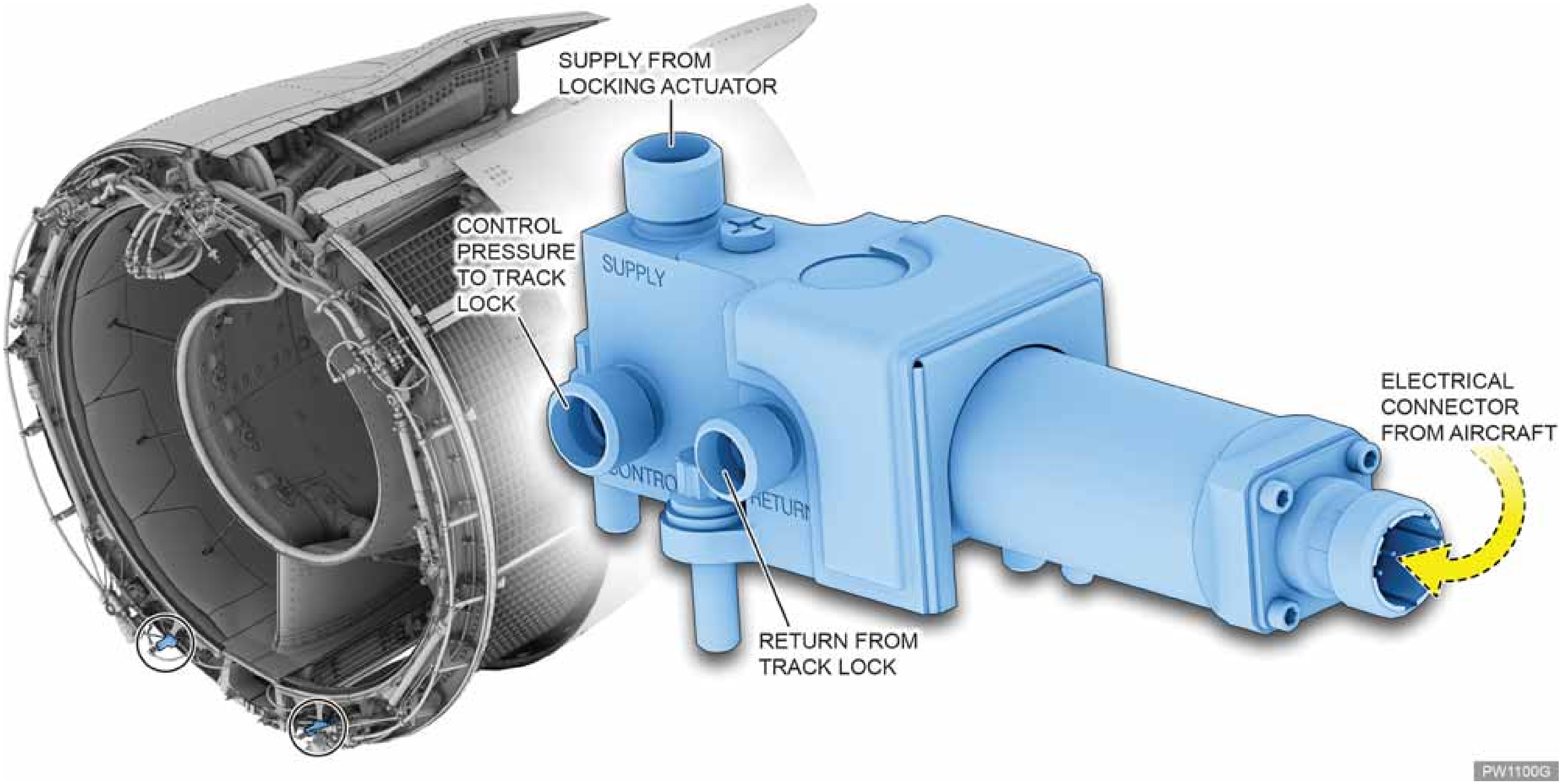
A track lock valve is mounted to a bracket that is attached to the torque box of each thrust reverser door at approximately 6:00.

Description

Each track lock valve is independently controlled by a 115V AC aircraft signal, which is external to the TRAS and provides fully independent control of the track locks. Track lock valves are considered part of the “third line of defense” to prevent inadvertent deployment of the thrust reverser during flight.

Operation:

When energized, the track lock valves allow fluid to be ported to the track locks, unlocking them for deployment of the thrust reverser.



THRUST REVERSER ACTUATION SYSTEM (TRAS) – TRACK LOCK VALVES

THRUST REVERSER SYSTEM

Thrust Reverser Actuation System (TRAS) (Cont.)

Track Locks LRU PMT

Purpose:

If the mechanical locking system fails to retain translating sleeves, track locks prevent the transcowl from deploying past the stowed position.

Location:

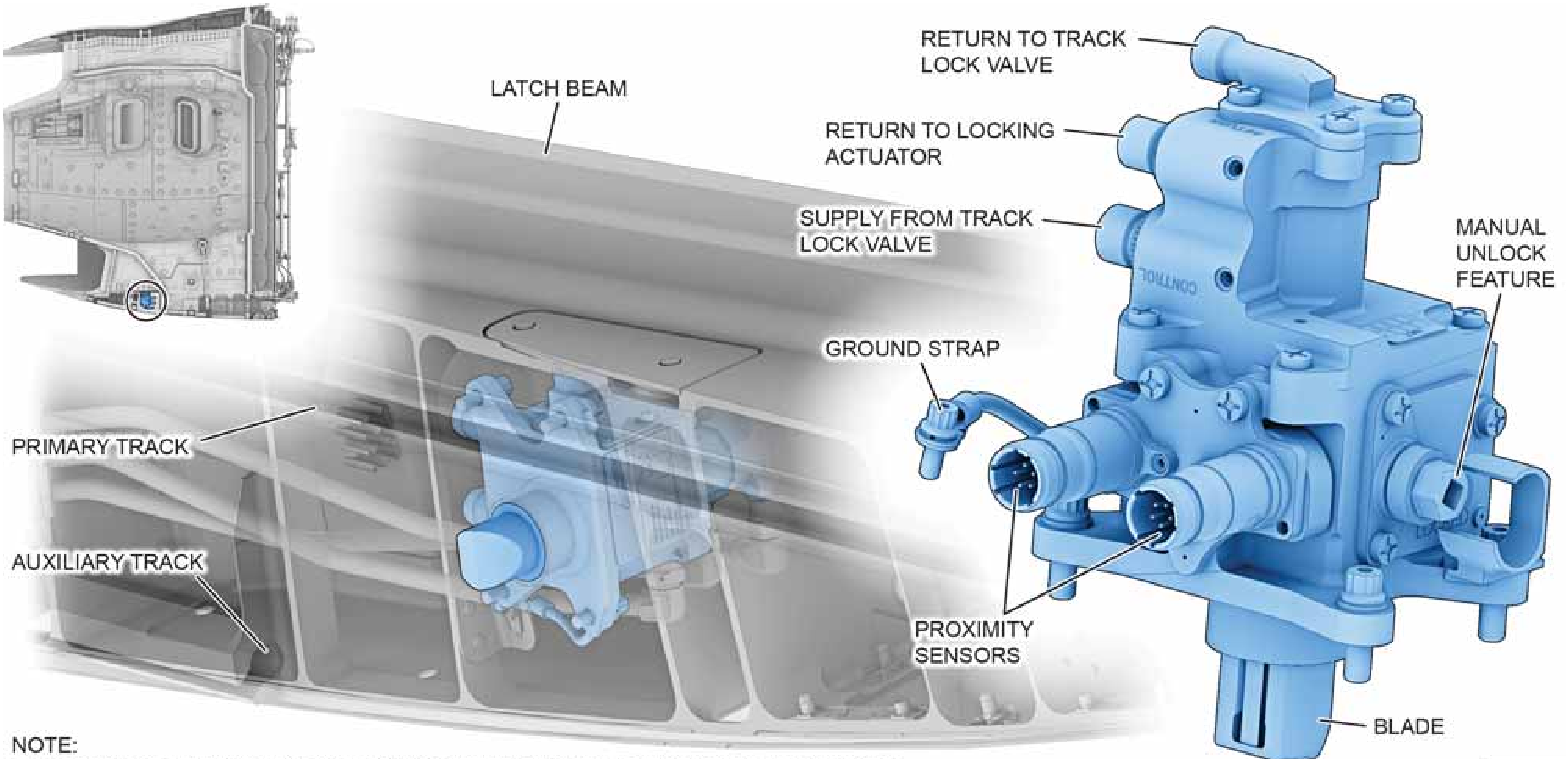
A track lock is mounted to the aft section of each latch beam.

Description:

Each track lock incorporates two proximity sensors which provide lock/unlock status to the EEC. A track lock is biased to the locked position by four springs between the blade and the piston.

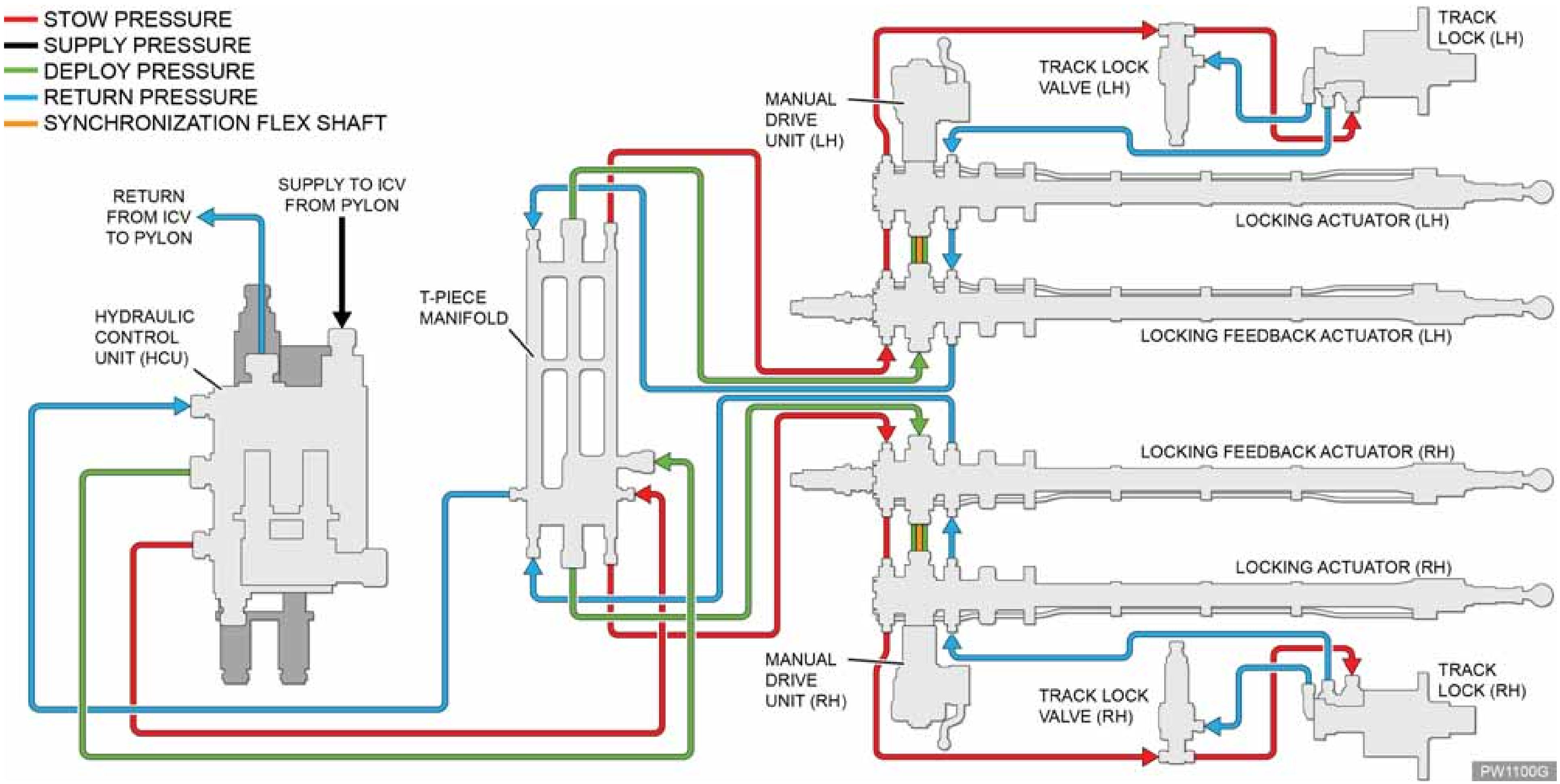
Operation:

1. Once the track lock solenoid is commanded open by the aircraft, the solenoid energizes, and the blade on the track lock actuator moves to the unlocked position.
2. Proximity sensor targets move to the “far” position, allowing them to send redundant signals to the aircraft that indicate the track lock is unlocked.
3. The thrust reverser deploys.
4. When the track lock receives supply pressure ported from the energized track lock solenoid, the piston retracts the blade, allowing the track lock to unlock.
5. Once the track has translated outside of the stowed locking region, the track lock valve stays energized, allowing the track lock to remain unlocked until the TRAS is returned to the stowed position.



NOTE:
LEFT THRUST REVERSER DOOR COMPONENTS SHOWN. RIGHT DOOR IS IDENTICAL

THRUST REVERSER ACTUATION SYSTEM (TRAS) – TRACK LOCKS



THRUST REVERSER ACTUATION SYSTEM (TRAS) OPERATION

THRUST REVERSER SYSTEM

Door Opening System (DOS)

Purpose:

LRU PMT

The Door Opening System (also called the thrust reverser opening mechanism) opens and closes the thrust reverser doors to provide maintenance access to the engine core.

Location:

The DOS is located in the fan compartment. It is attached to the fan case on one end and the thrust reverser torque box on the other end.

Description:

The DOS has two actuators, one for each thrust reverser door. Each actuator is used to both open and close the door.

On one end, the actuator has an accumulator assembly and a quick disconnect, which is used with a manual hydraulic hand pump coupled to the actuator.

On the opposite end, a breather housing filter facilitates bleed air when the actuator is extended or retracted. This piston rod end has a spherical bearing that attaches to the torque box.

The accumulator has a filter that prevents debris from entering the actuator hydraulic system.

Operation:

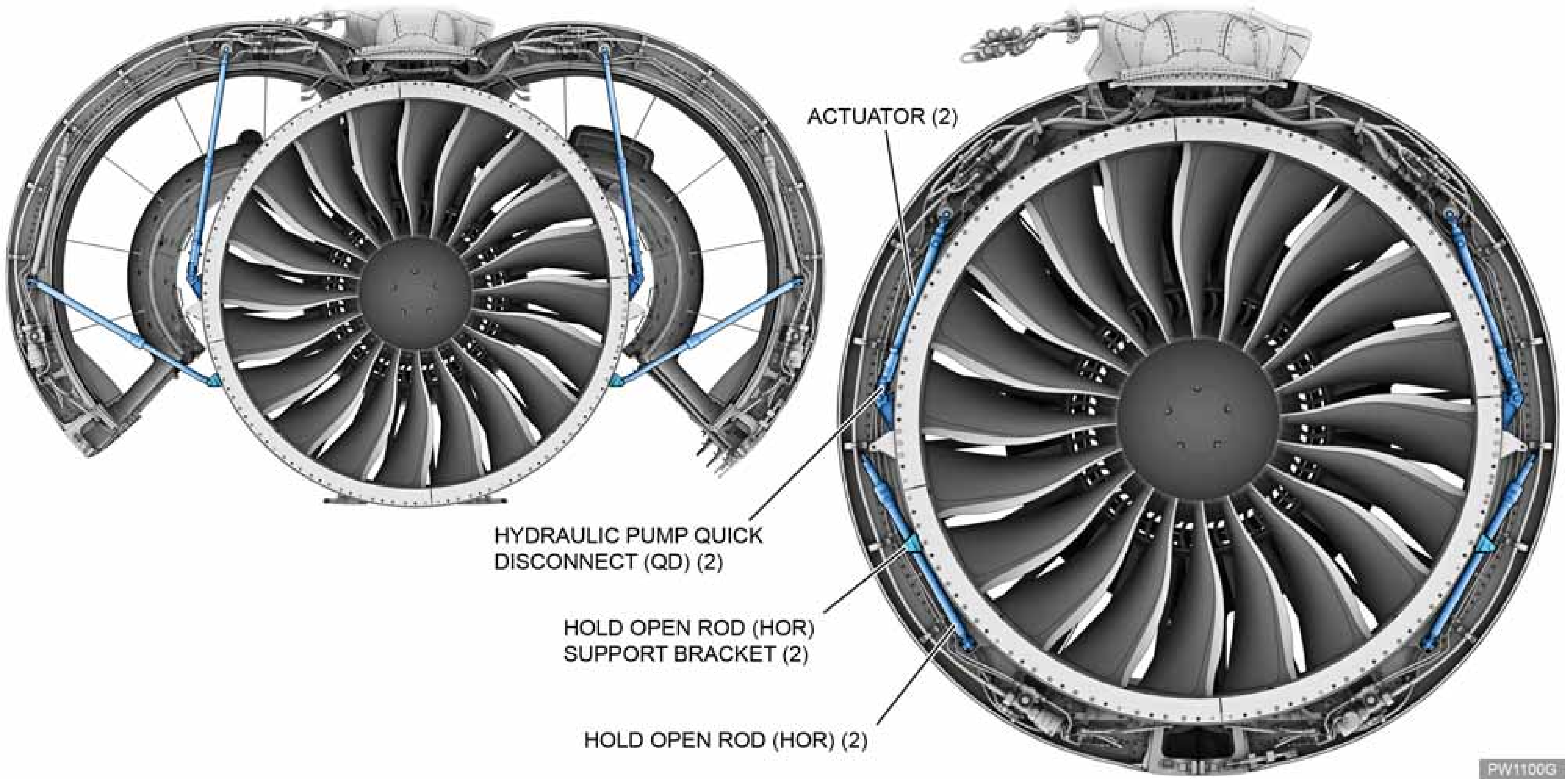
To open the thrust reverser doors, the fan cowl doors must be opened first in order to access the DOS.

As the hand pump is engaged, hydraulic fluid is pressurized. The pressure within the actuator holds the door open. A Hold Open Rod (HOR) can then be hooked into the fan case bracket to prevent the doors from closing

To close the thrust reverser doors, the hand pump is used to maintain pressure in the actuators as the HORs are disengaged from the brackets. A release valve in the hand pump reduces pressure in the actuator to lower the door.

The DOS accumulator is designed to limit closing speed and maintain a safe pressure in the actuators during operation.

Each door must be opened or closed separately.



THRUST REVERSER SYSTEM – DOOR OPENING SYSTEM (DOS)

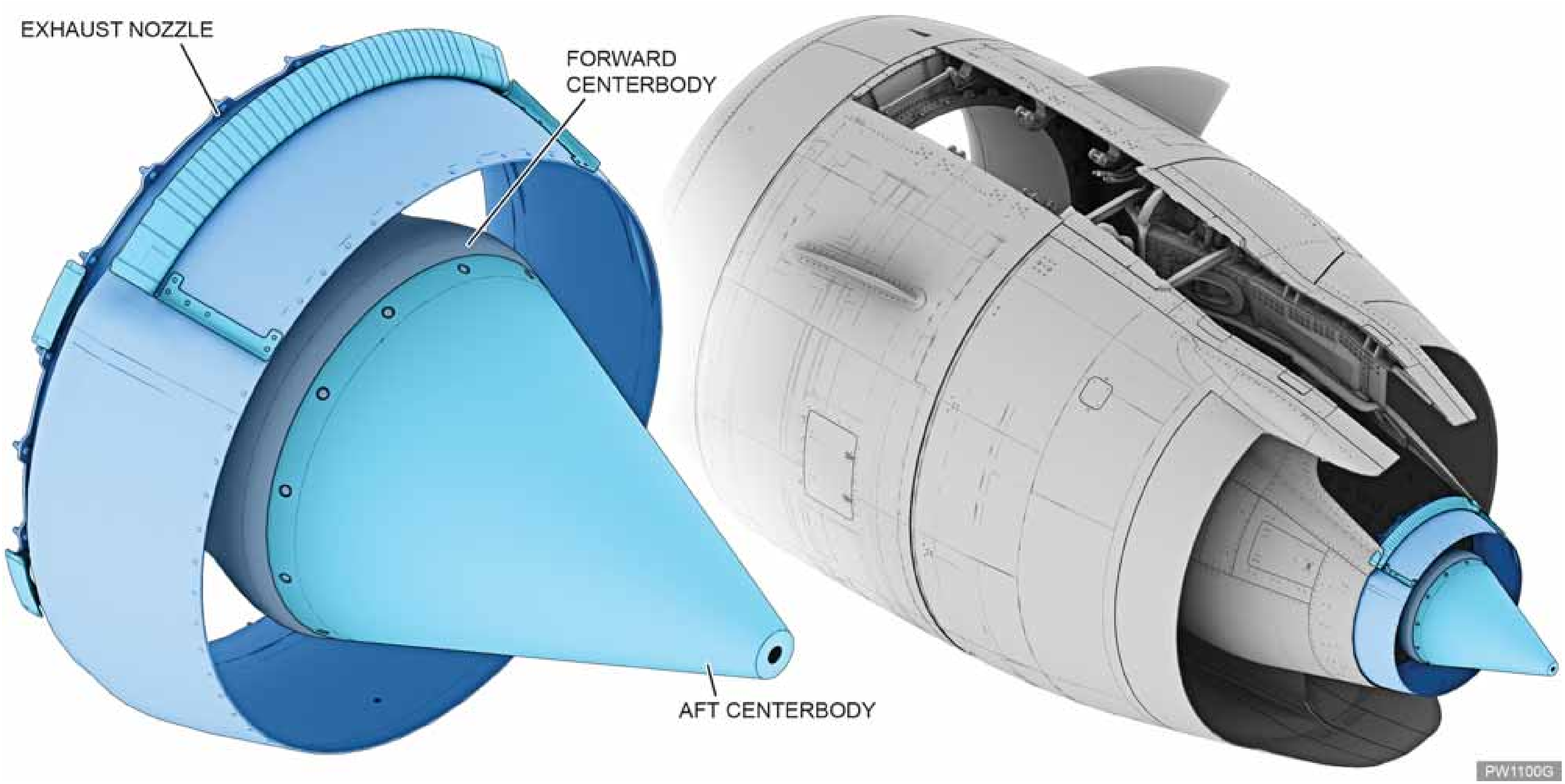
TURBINE EXHAUST SYSTEM

The Turbine Exhaust System is a cylindrical barrel and cone that makes a smooth exit for fan air and engine exhaust during engine operation. The system helps mix the fan bypass air with the turbine exhaust air. It reduces exhaust noise and helps increase thrust and performance.

The system is installed on the aft flange of the engine.

An exhaust nozzle assembly is composed of an exhaust nozzle and a centerbody (also known as the exhaust plug). The assembly helps to control the engine exhaust gas flow and send the gas aft. It also supplies an aerodynamically smooth surface for the fan air from the thrust reverser.

The system also incorporates drainage provisions to expel any hazardous fluids or vapors. Drainage outlets are found at 6:00 for the nozzle assembly and the exhaust plug.



TURBINE EXHAUST SYSTEM

TURBINE EXHAUST SYSTEM (Cont.)

Exhaust Nozzle

Purpose:

LRU

The turbine exhaust nozzle provides an efficient exit path for the engine exhaust gases leaving the LPT at a velocity and direction required to produce forward thrust.

Location:

The exhaust nozzle is a tapering cylindrical barrel installed on the *To* flange of the Turbine Exhaust Case.

Description:

The exhaust nozzle consists of these components:

- fire seals
- cross flow blockers.

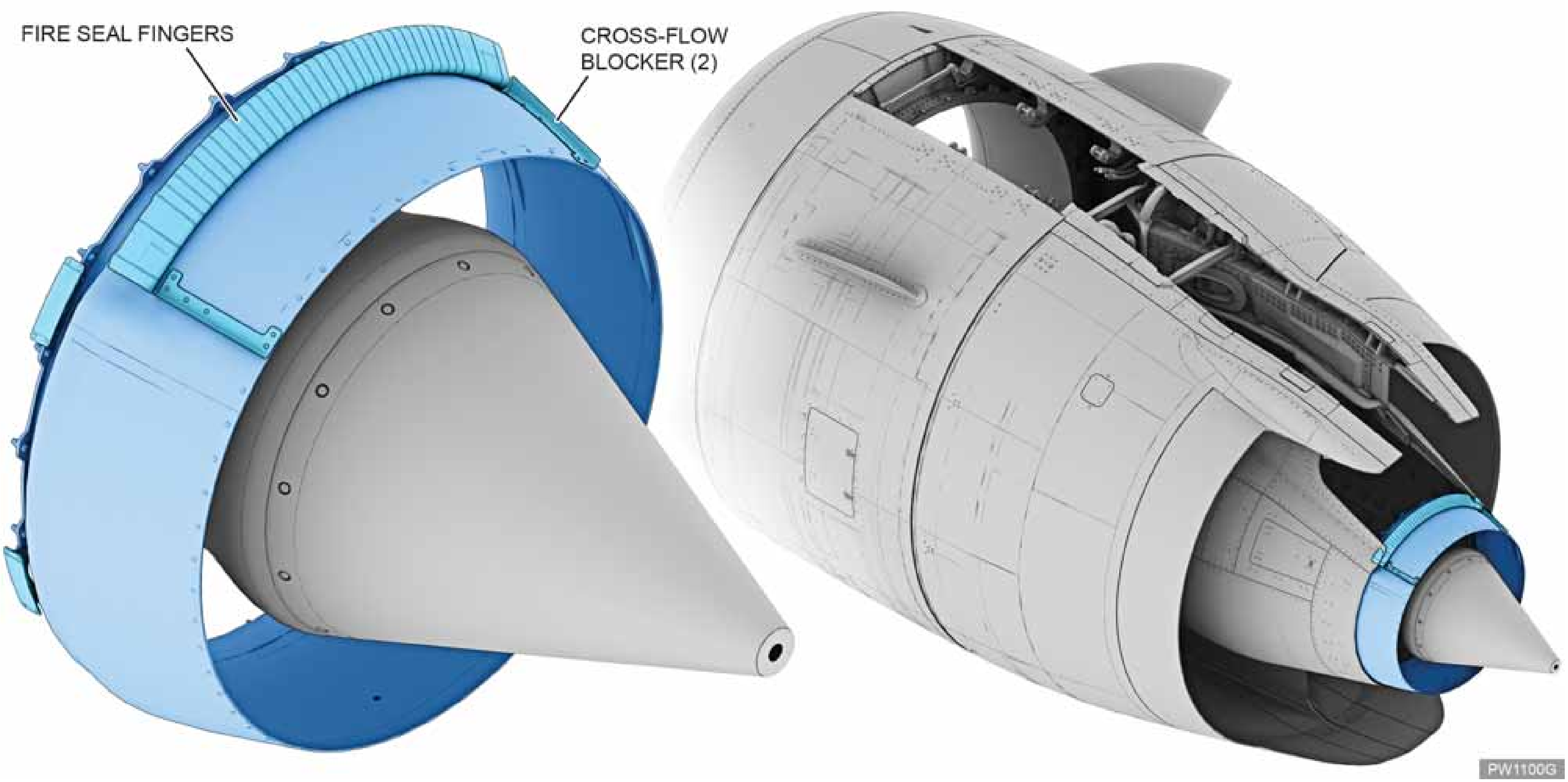
The forward outer surface aligns with the thrust reverser inner duct surface. The inner surface makes the outer contour of the engine exhaust.

The fire seal fingers (also known as “turkey feathers”), prevent flames from exiting or entering the core compartment area in the unlikely event of a fire.

A fairing provides clearance between the exhaust and the pylon while maintaining the outer flow surface continuity.

Two cross flow blockers, one on each side of the Aft Pylon Fairing (APF), maintain performance by preventing exhaust flow from entering the cavity between the exhaust nozzle and the pylon.

The top of the exhaust nozzle has a pylon fire seal. Diverters to the left and right of the pylon seal help prevent cross flow of the exhaust under the pylon aft fairing. The nozzle is not in a flammable fluid zone.



TURBINE EXHAUST SYSTEM – EXHAUST NOZZLE

TURBINE EXHAUST SYSTEM

Exhaust Nozzle

Description (Cont.):

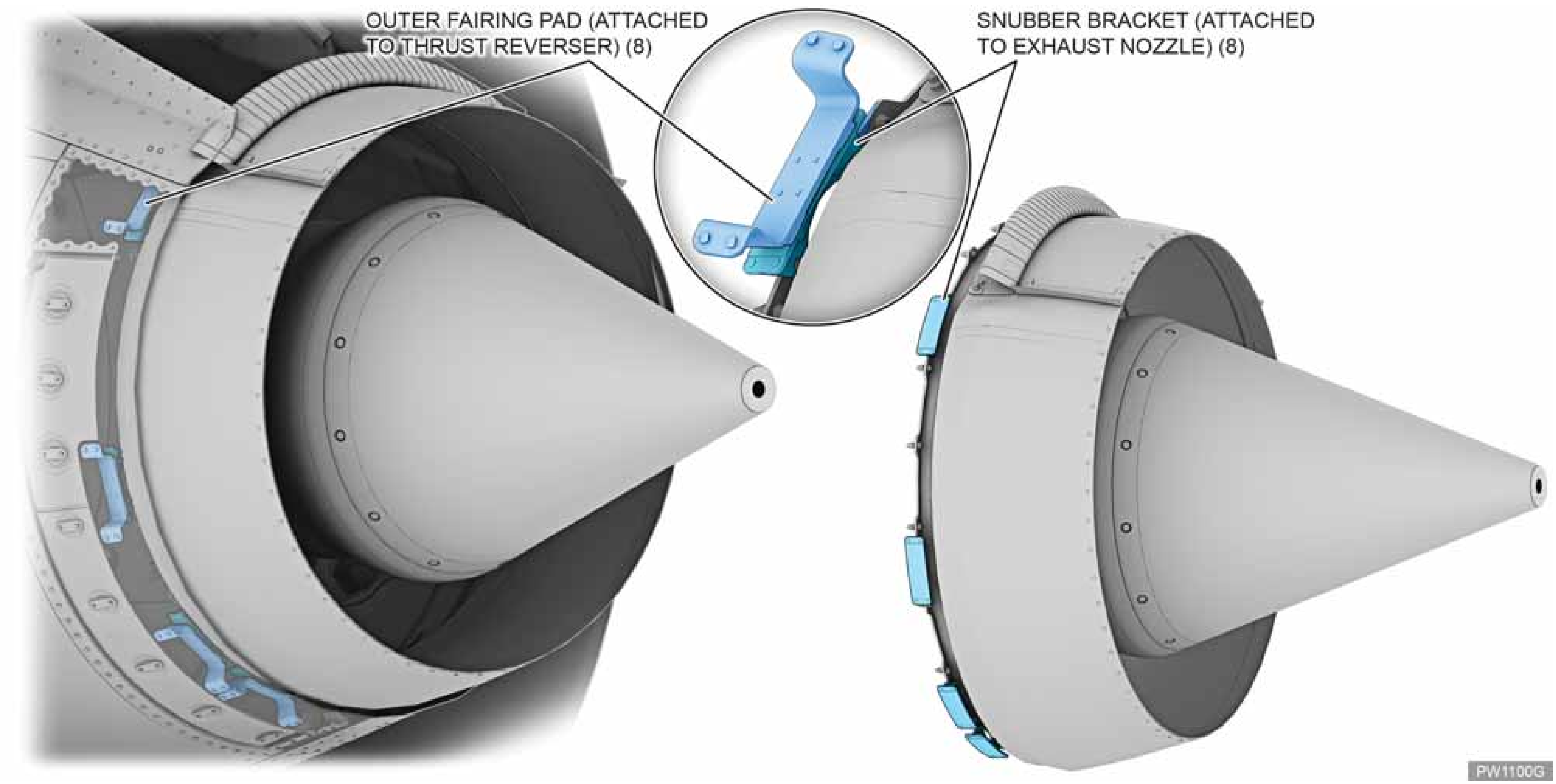
Eight outer fairing pads on the side provide protection to the exhaust nozzle during the translating sleeve operation. The exhaust nozzle assembly is made of Inconel alloys.

The attachment flange has alignment pin holes at 12:00 and 6:00 to position the drain provisions.

Note that the exhaust nozzle can be removed with the engine lift bracket installed. Scallops have been designed to clear the lift bracket nuts.

A snubber bracket assembly limits deflections of the thrust reverser during flight. The assembly interfaces between the nozzle assembly and the thrust reverser, and includes a coated wear pad to prevent premature wear of the snubber bracket.

A total of eight snubber bracket assemblies are located on the nozzle assembly, four to each side. The wear pads are attached to the snubber bracket assembly with four countersunk rivets.



TURBINE EXHAUST SYSTEM – SNUBBER BRACKETS

TURBINE EXHAUST SYSTEM (Cont.)

Centerbody (Exhaust Plug)

Purpose: LRU

The centerbody helps to control the engine exhaust gas flow and helps the nozzle to send gas aft.

Location:

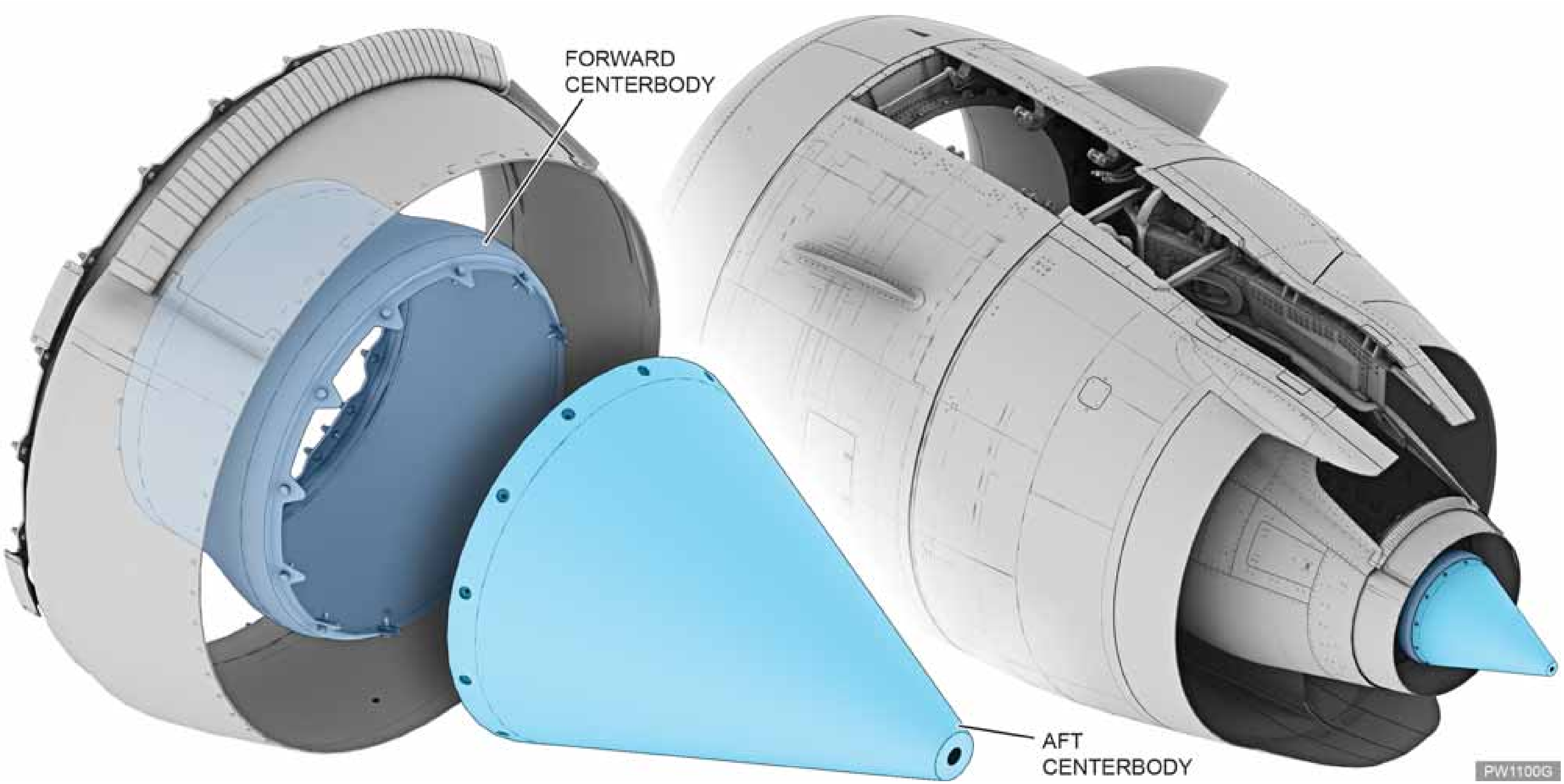
The assembly is attached to the rear of the Turbine Exhaust Case.

Description:

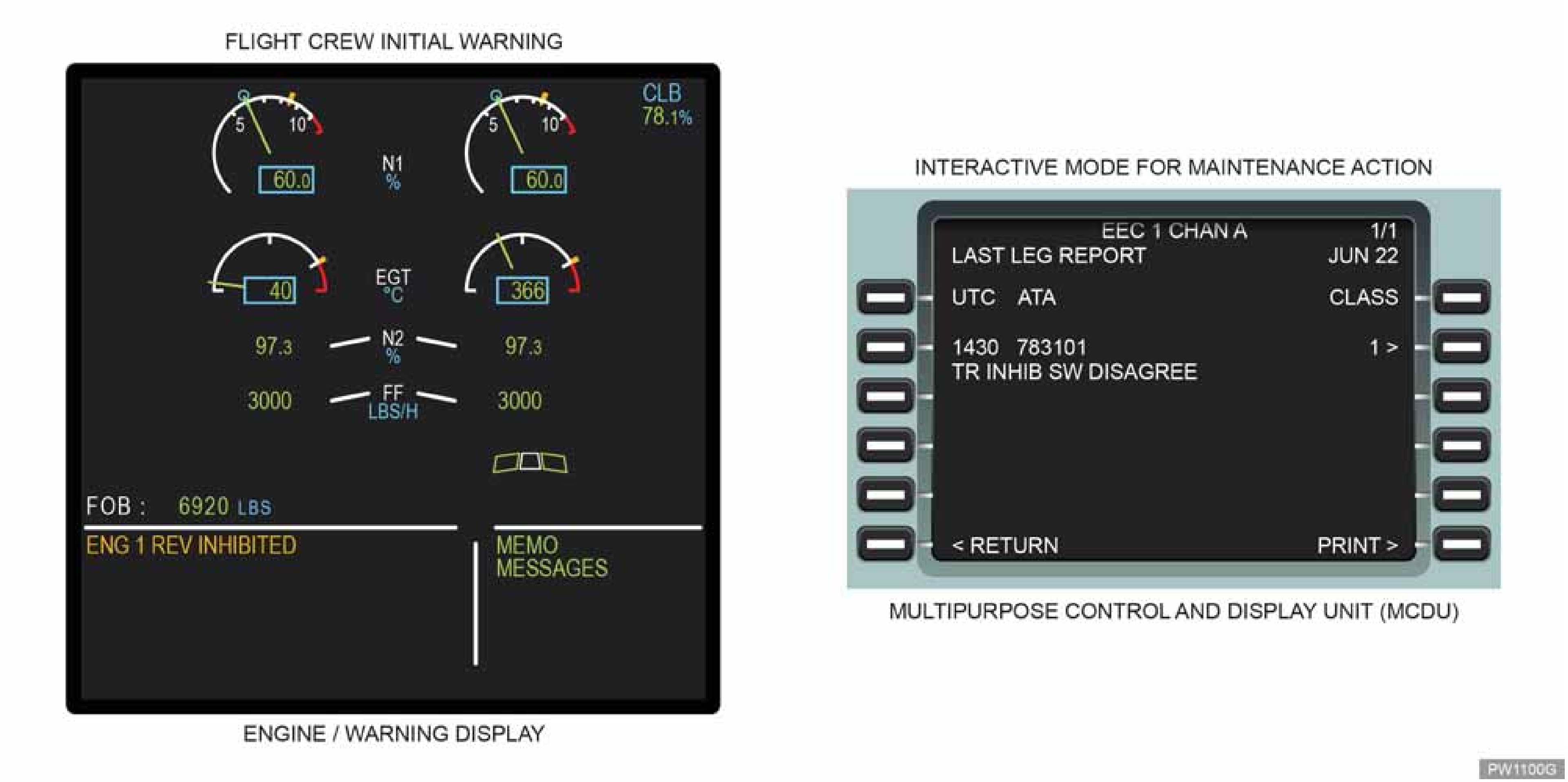
The centerbody provides an aerodynamic smooth surface for exhaust airflow and is designed to accelerate exhaust flow to high speeds.

The centerbody has both forward and aft sections. The forward section is installed with 20 bolts on the *Ti* flange of the engine's TEC. The aft section is attached to the forward section with 12 bolts and nut plates.

The forward centerbody drain is at 6:00. Two alignment pins at 12:00 and 5:00 on the forward centerbody flange facilitate proper clocking of the centerbody drain provisions.



TURBINE EXHAUST SYSTEM – CENTERBODY (EXHAUST PLUG)



SAMPLE ECAM MESSAGES FOR ATA 78

CHAPTER 10

ANCILLARY SYSTEMS

ATA 24-20 Alternating Current Generating

26 Fire Protection

29 Hydraulic Power

30 Ice and Rain Protection

36 Pneumatic

SYMBOLS

Symbols used in this guide are explained below.

Special tooling is required.

LRU The component is a Line Replaceable Unit (LRU).

PMT A Post Maintenance Test is required.

WARNING Avoid injury by following guidelines listed under this symbol.

CAUTION Avoid damage to equipment by following guidelines listed under this symbol.

OBJECTIVES

1. Describe the purpose of each of these PW1100G-JM ancillary systems:
    - Alternating Current Generating
    - Fire Protection
    - Hydraulic Power
    - Ice and Rain Protection
    - Pneumatic.
2. Locate system components.
3. Identify Line Replaceable Units (LRUs)

OVERVIEW

Ancillary systems designed to interface with the engine and aircraft are critical to safe operation and optimum performance. They include the systems below, which are installed on the engine but are not supplied by Pratt & Whitney:

- Alternating Current Generating
- Fire Protection
- Hydraulic Power
- Ice and Rain Protection
- Pneumatic.

Components for these systems are divided into two groups: the Buyer Furnished Equipment (BFE) and the Engine Build Up (EBU) system.

Safety Conditions

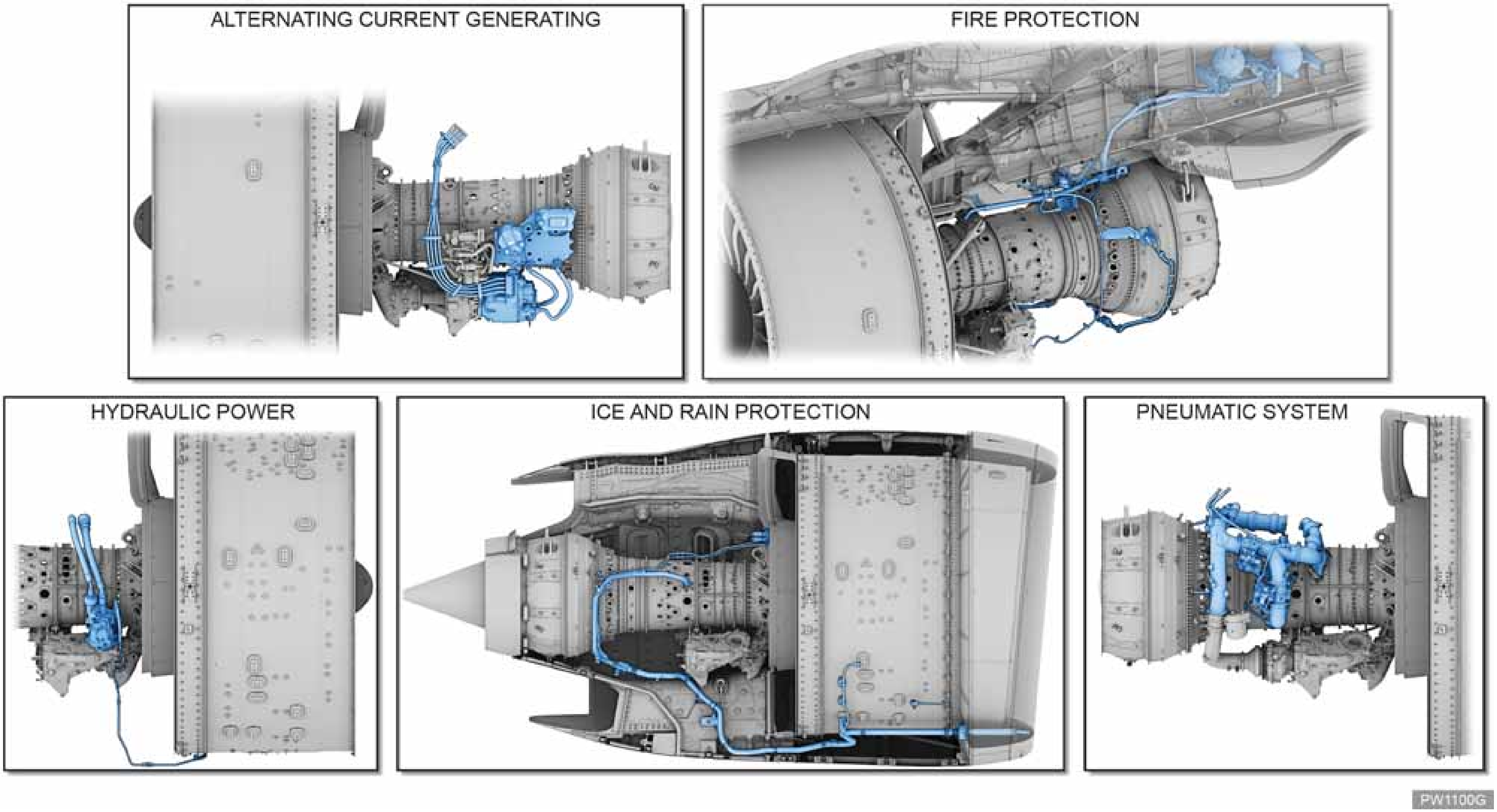
WARNING

BE CAREFUL WHEN YOU WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE AND ENGINE OIL CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS WARNING, IMJURY CAN OCCUR.

REFER TO THE SDS FOR ALL MATERIAL USED AND THE MANUFACTURER'S SAFETY INSTRUCTIONS FOR ALL EQUIPMENT USED. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

YOU MUST HOLD A SECOND WRENCH TO HOLD THE MATING PARTS WHEN YOU LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

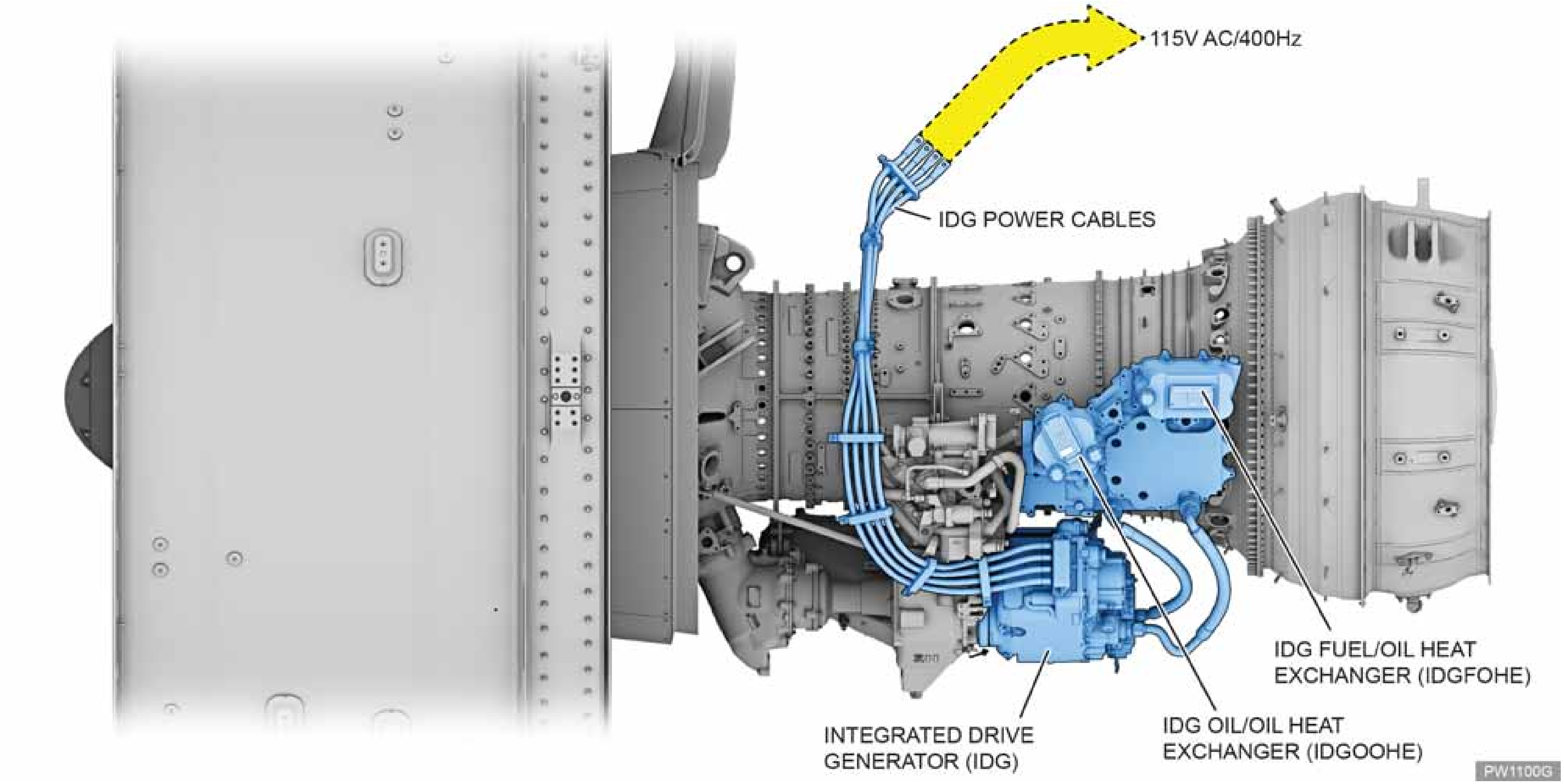


ANCILLARY SYSTEMS

ALTERNATING CURRENT GENERATING SYSTEM

The Alternating Current Generating System produces constant frequency electrical power for distribution to the aircraft. Components are listed below.

- Integrated Drive Generator — IDG
- IDG Oil/Oil Heat Exchanger — IDGOOHE
- IDG Fuel/Oil Heat Exchanger — IDGFOHE
- Interconnecting power cables and control wiring



ALTERNATING CURRENT GENERATING SYSTEM

ALTERNATING CURRENT GENERATING SYSTEM (Cont.)

Integrated Drive Generator (IDG)

Purpose:

LRU PMT

The Integrated Drive Generator hydroelectrically converts variable speed shaft power into a constant, three-phase voltage of 115/120V AC at 400Hz.

Location:

The IDG is located at the rear of the Main Gearbox (MGB) at 6:00.

Description:

The IDG consists of a Constant Speed Drive (CSD) unit and a generator installed in a magnesium cast housing. The housing is connected to the MGB by a Quick Attach/Detach (QAD) ring.

Operation:

Once the Integrated Drive Generator has converted variable speed shaft power into a constant frequency, the speed is then sent from the CSD to the generator, which keeps a frequency of 400Hz.

Safety Conditions

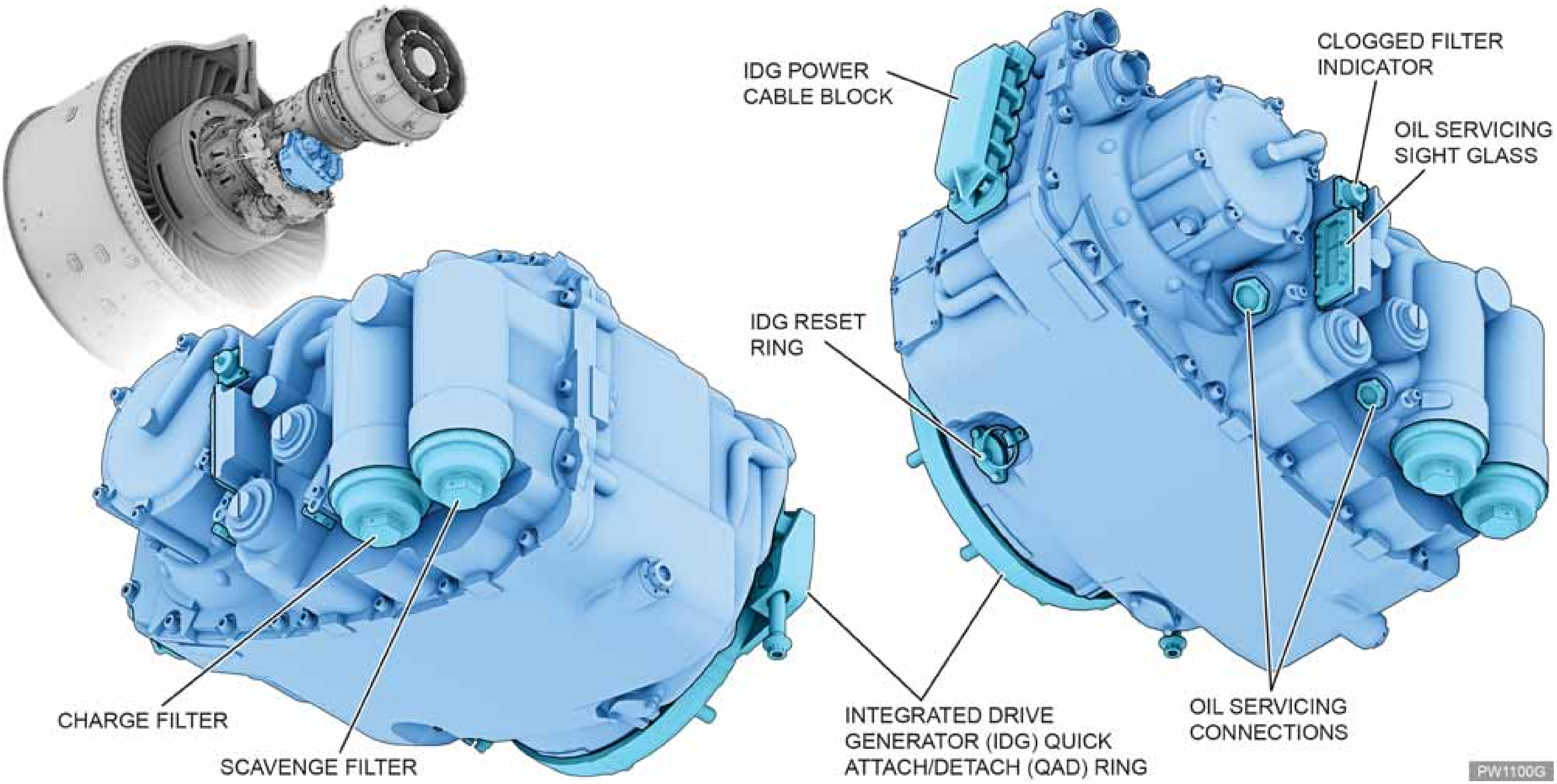
CAUTION

MAKE SURE THAT YOU APPLY ONLY SUFFICIENT PRESSURE WITH THE JACK TO HOLD THE WEIGHT OF THE IDG. TOO MUCH PRESSURE ON THE IDG OR FAILURE TO HOLD THE IDG CORRECTLY CAN CAUSE DAMAGE TO THE INPUT SHAFT SEAL.

The CSD unit has a disconnect mechanism to disengage the input shaft attached to the MGB. Disconnection is necessary to prevent internal mechanical damage if an IDG oil cooling system failure should occur. The input shaft is disengaged via a switch on the flight deck electrical panel that energizes the disconnect solenoid. The IDG cannot be reconnected in flight.

If the IDG is operated for 50 hours in the disconnect mode without reset, the component must be removed. Reset is done only on the ground with the engine shut down, by manually moving the pawl with the IDG reset ring.

IDG drive splines are lubricated by the engine oil cooling system, which supplies a stream of oil to the center of the shaft. Oil from the shaft goes through the splines and is released into the gearbox cavity through radial holes in the shaft. The IDG has an oil sight glass to check oil level and facilitate correct oil service.



ALTERNATING CURRENT GENERATING SYSTEM – INTEGRATED DRIVE GENERATOR (IDG)

ALTERNATING CURRENT GENERATING SYSTEM (Cont.)

IDG Oil/Oil Heat Exchanger (IDGOOHE)

LRU PMT

Purpose:

The IDG Oil/Oil Heat Exchanger controls the temperature of IDG oil.

Location:

The IDGOOHE is mounted to the Thermal Management System manifold at 9:00.

Description:

Proper temperature of IDG oil is critical for frequency control, as well as for lubrication of IDG bearings and gears. Heat is transferred from the IDG's self-contained, passive oil system to the Oil/Oil Heat Exchanger.

Operation:

In hot conditions, oil flows from the IDG to the core of the Oil/Oil Heat Exchanger, transferring heat. This usually occurs when the engine is at idle and the generator oil system is hotter than the engine oil system.

Safety Conditions

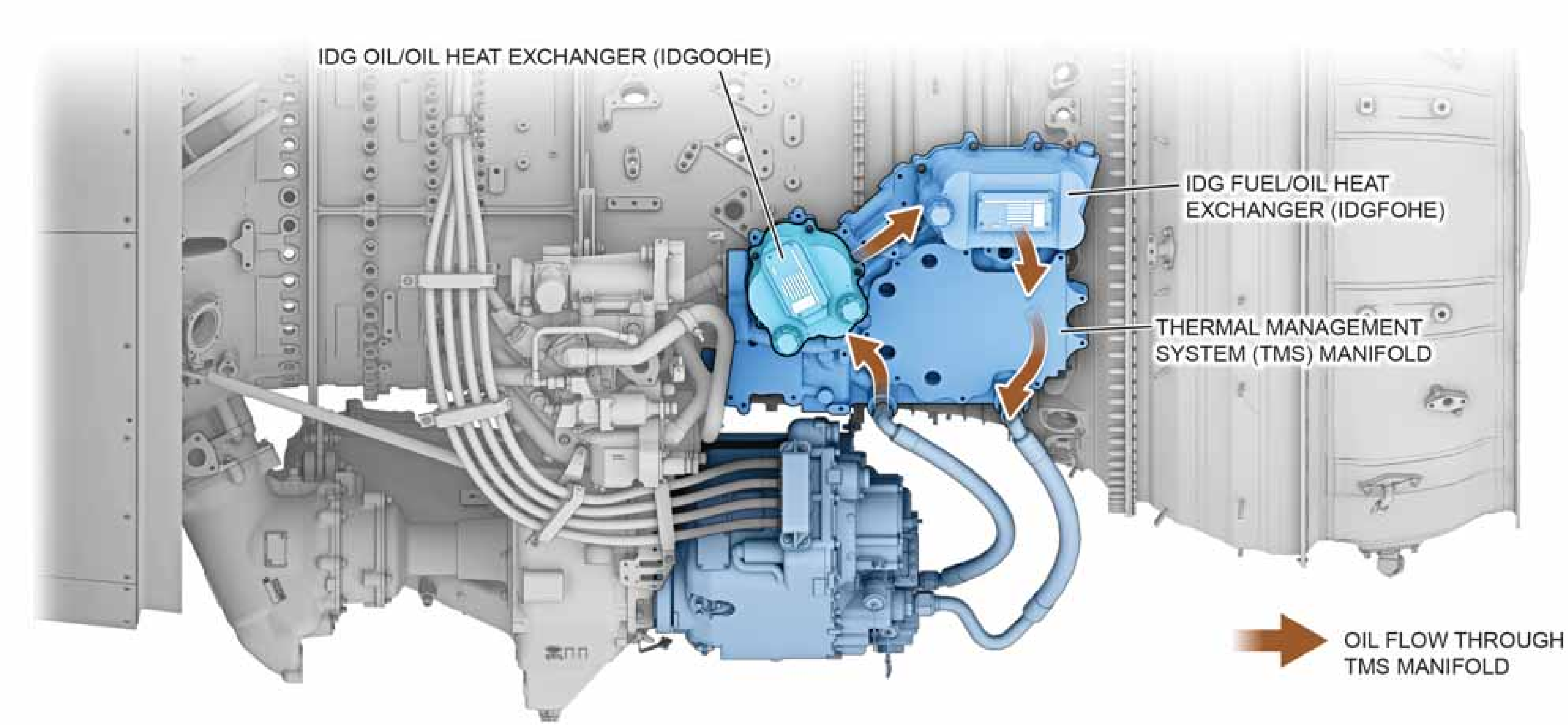
WARNING

WAIT 5 MINUTES MINIMUM TO MAKE SURE THAT THE OIL SYSTEM IS NOT PRESSURIZED BEFORE DOING THIS PROCEDURE. IF YOU DO NOT OBEY THIS WARNING, INJURY CAN OCCUR.

CAUTION

DO NOT LET THE FUEL SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE UNWANTED FUEL WITH A CLOTH. THE FUEL CAN CAUSE DAMAGE TO SOME ENGINE PARTS.

In normal conditions, heat is transferred to the IDG oil from the engine oil. The oil continues downstream to the IDG Fuel/Oil Heat Exchanger, where more cooling may take place.



(ENGINE FUEL/OIL HEAT EXCHANGER REMOVED FOR CLARITY)

ALTERNATING CURRENT GENERATING SYSTEM – IDG OIL/OIL HEAT EXCHANGER

ALTERNATING CURRENT GENERATING SYSTEM (Cont.)

IDG Fuel/Oil Heat Exchanger (IDGFOHE)

Purpose:

LRU PMT

The IDG Fuel/Oil Heat Exchanger controls the temperature of IDG oil.

Location:

The IDGFOHE is mounted to the Thermal Management System manifold at 9:30.

Description:

The IDGFOHE removes heat from IDG oil by transferring it to the engine fuel. The cooled oil is then sent to lubricate and cool the IDG.

Operation:

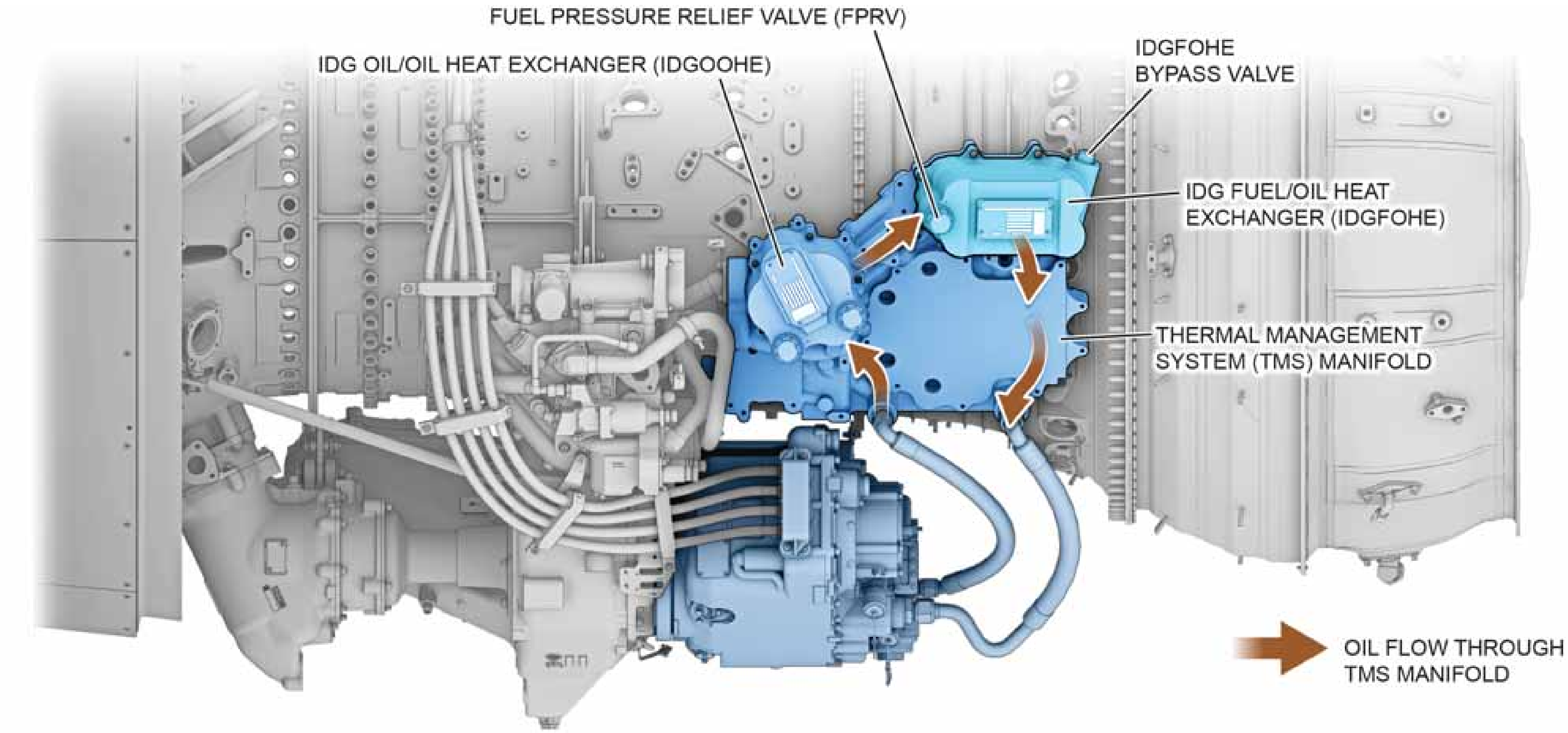
Engine fuel flows through internal tubes in the IDGFOHE. The tubes pass through the IDG oil core, which has baffles to increase the surface area for heat transfer.

An oil bypass valve in the IDGFOHE helps to hold the IDG oil minimum temperature by mixing uncooled oil from the IDG with cooled oil from the IDGFOHE. The oil bypass valve is a passive-operation, viscosity control valve and operates independent of the Electronic Engine Control.

At engine startup, when IDG oil temperature is low, the valve is in full bypass position. At moderate temperatures the valve controls the oil flow, mixing uncooled oil from the IDG and cooled oil from the fuel/oil heat exchanger. The oil is then returned to the IDG.

At the high end of the IDG oil temperature range, the valve is in non-bypass (full cooling) position, and 100 percent of the IDG oil flows through the fuel/oil heat exchanger.

The Fuel Pressure Relief Valve (FPRV) is installed in the IDGFOHE. It is normally in the closed position. If the inlet pressure to the IDGFOHE rises above a preset limit, the FPRV will open to allow fuel to exit the IDGFOHE through a separate passage.



(ENGINE FUEL/OIL HEAT EXCHANGER REMOVED FOR CLARITY)

ALTERNATING CURRENT GENERATING SYSTEM – IDG FUEL/OIL HEAT EXCHANGER

ALTERNATING CURRENT GENERATING SYSTEM (Cont.)

Power Cables

Purpose: LRU PMT

The IDG power cables conduct power from the IDG to the aircraft.

Location:

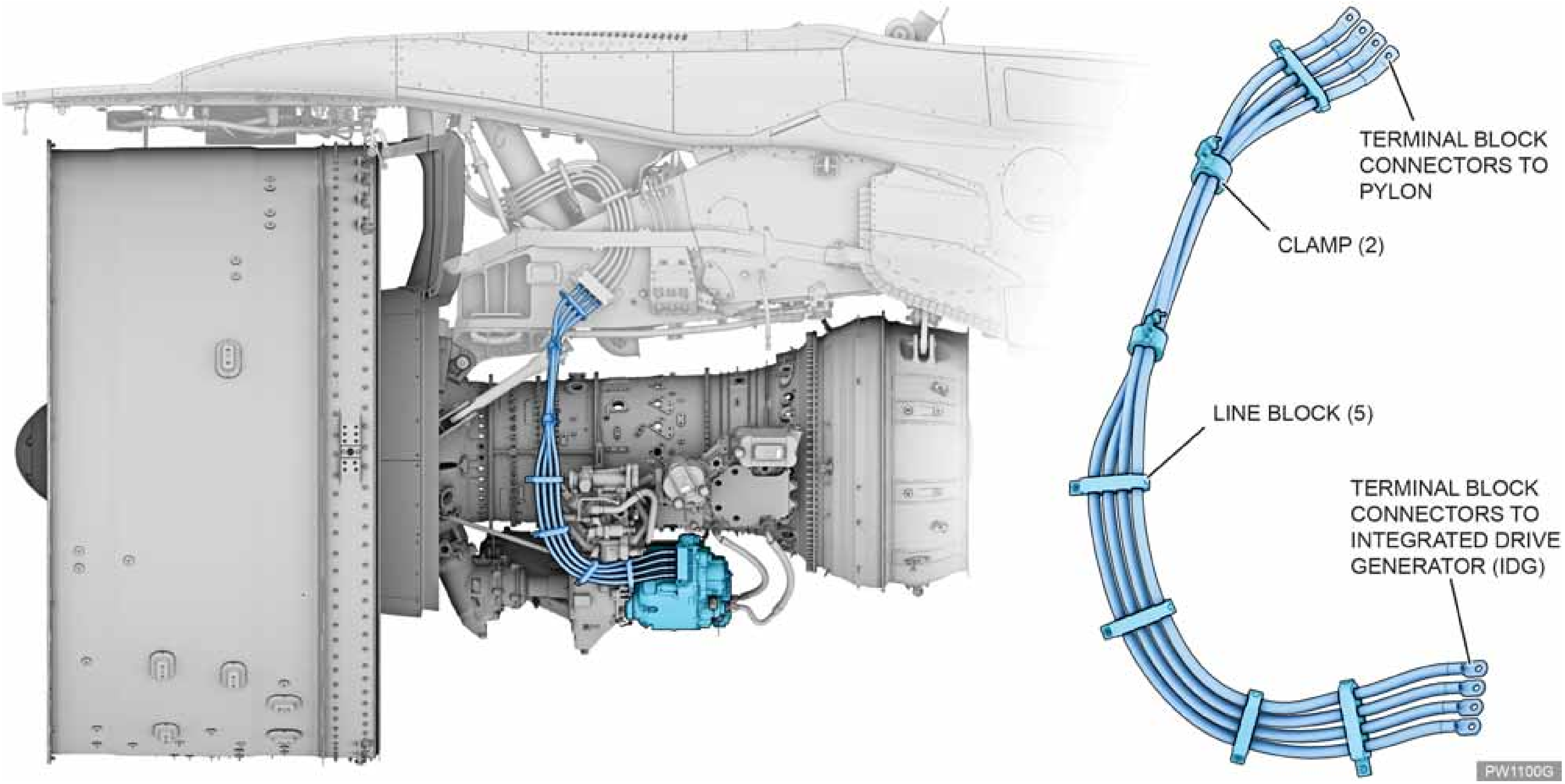
The cables are located on the left side of the engine core.

Description:

Four individual (unbundled) cables are connected to terminal blocks at each end. Line blocks and clamps hold the cables in position along the left side of the engine core.

Operation:

The cables supply IDG-generated 115V AC/400Hz power to operate the aircraft electrical systems.



ALTERNATING CURRENT GENERATING SYSTEM – IDG POWER CABLES

ALTERNATING CURRENT GENERATING SYSTEM (Cont.)

IDG Oil Servicing

PMT

Wait at least five minutes after engine shutdown before you perform the oil check below.

1. Use a flashlight to find the oil level sight glass on the rear side of the IDG.

2. Wipe the sight glass with a clean, lint-free cotton cloth.

3. To service the oil, use the service cart. Fill the IDG with PWA 521 Engine Oil (P03-001) until a minimum of one quart (946.3 grams) of oil comes out of the overflow drain hose.

Safety Conditions

WARNING

BE CAREFUL WHEN YOU WORK WITH THE OIL SYSTEM AND USE SUFFICIENT PROTECTION FOR THE HANDS AND EYES. THE OIL IS HOT AND CAN CAUSE BURNS.

YOU MUST PUT THE DRAIN HOSE INTO A COLLECTOR/CONTAINER BEFORE YOU CONNECT THE DRAIN HOSE TO THE IDG OVERFLOW DRAIN CONNECTOR. MAKE SURE THE DRAIN HOSE HANGS STRAIGHT DOWN. MAKE SURE THAT THE HOSE IS ABOVE AND NOT INTO THE FLUID IN THE COLLECTOR/CONTAINER. WHEN YOU CONNECT THE DRAIN HOSE TO THE IDG, YOU RELEASE THE PRESSURE IN THE IDG OIL SYSTEM. WHEN YOU RELEASE THE PRESSURE, OIL AND AIR WILL SPRAY FROM THE END OF THE HOSE.

SOME HOT OIL UNDER PRESSURE CAN COME OUT OF THE OVERFLOW DRAIN HOSE WHEN IT IS CONNECTED.

CAUTION

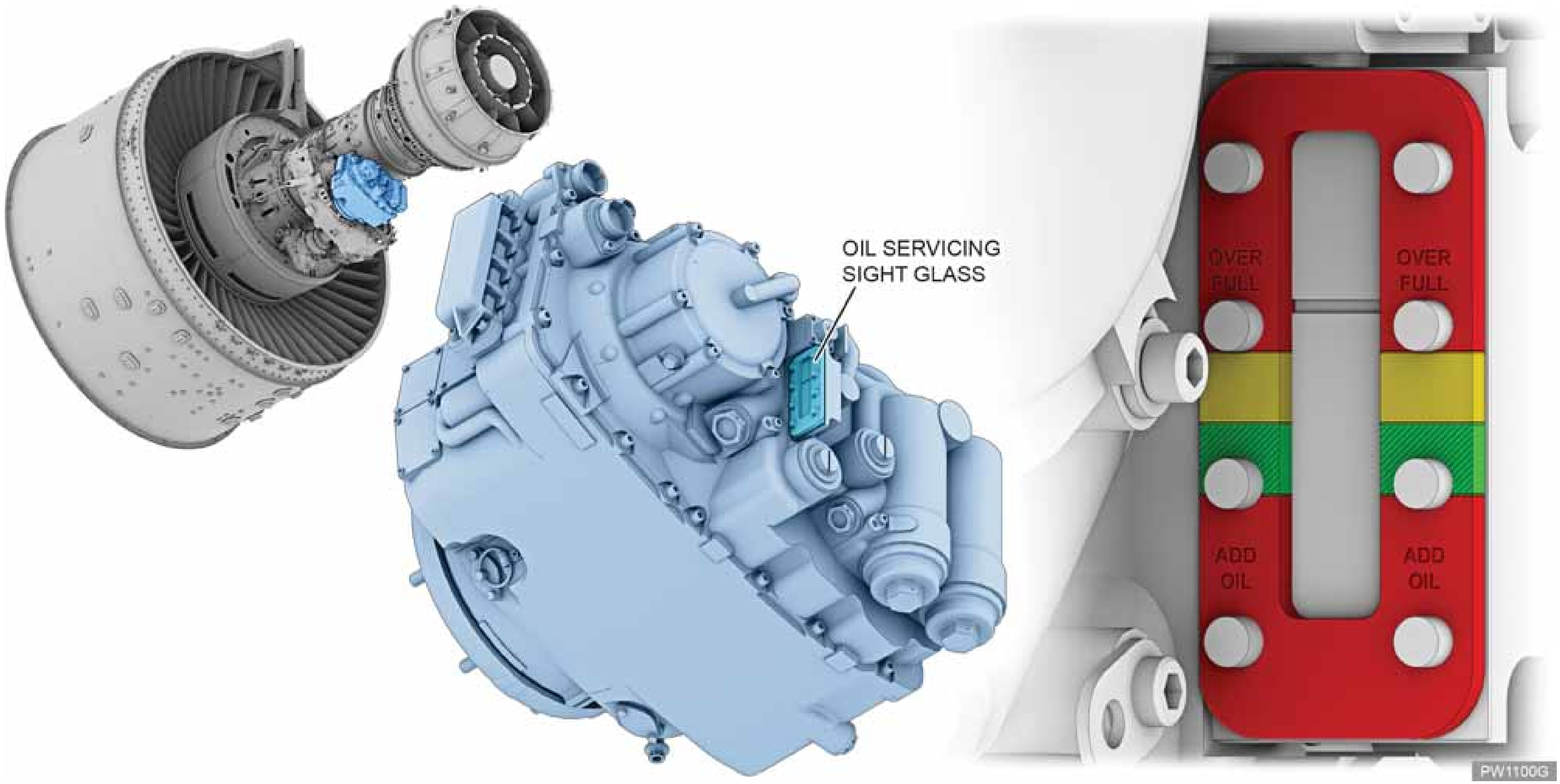
YOU MUST USE THE CORRECT SPECIFICATION OF CLEAN NEW OIL WHEN YOU ADD OR REPLACE THE OIL IN THE IDG. INCORRECT OILS CAN CAUSE DAMAGE TO THE IDG.

SOLVENTS THAT CONTAIN CHLORINE SHOULD NOT BE USED TO CLEAN EQUIPMENT REQUIRED TO SERVICE THE IDG WITH OIL. CHLORINE CONTAMINATION CAN CAUSE RAPID DETERIORATION OF OIL AND SUBSEQUENT GENERATOR DAMAGE.

DO NOT CHANGE THE OIL IN A DISCONNECTED IDG. THE OPERATION OF A DEFECTIVE IDG CAN CAUSE DAMAGE TO EQUIPMENT.

MAKE SURE THE DRAIN VALVE HOSE IS CONNECTED TO THE OIL DRAIN TO THE CORRECT LEVEL IN THE IDG. TOO MUCH HEAT CAN OCCUR IF THE IDG IS FILLED WITH TOO MUCH OIL.

DO NOT DISCONNECT THE OVERFLOW DRAIN HOSE UNTIL THE FLOW DECREASES TO SINGLE DROPS.



ALTERNATING CURRENT GENERATING SYSTEM – IDG SERVICING (1 OF 2)

ALTERNATING CURRENT GENERATING SYSTEM

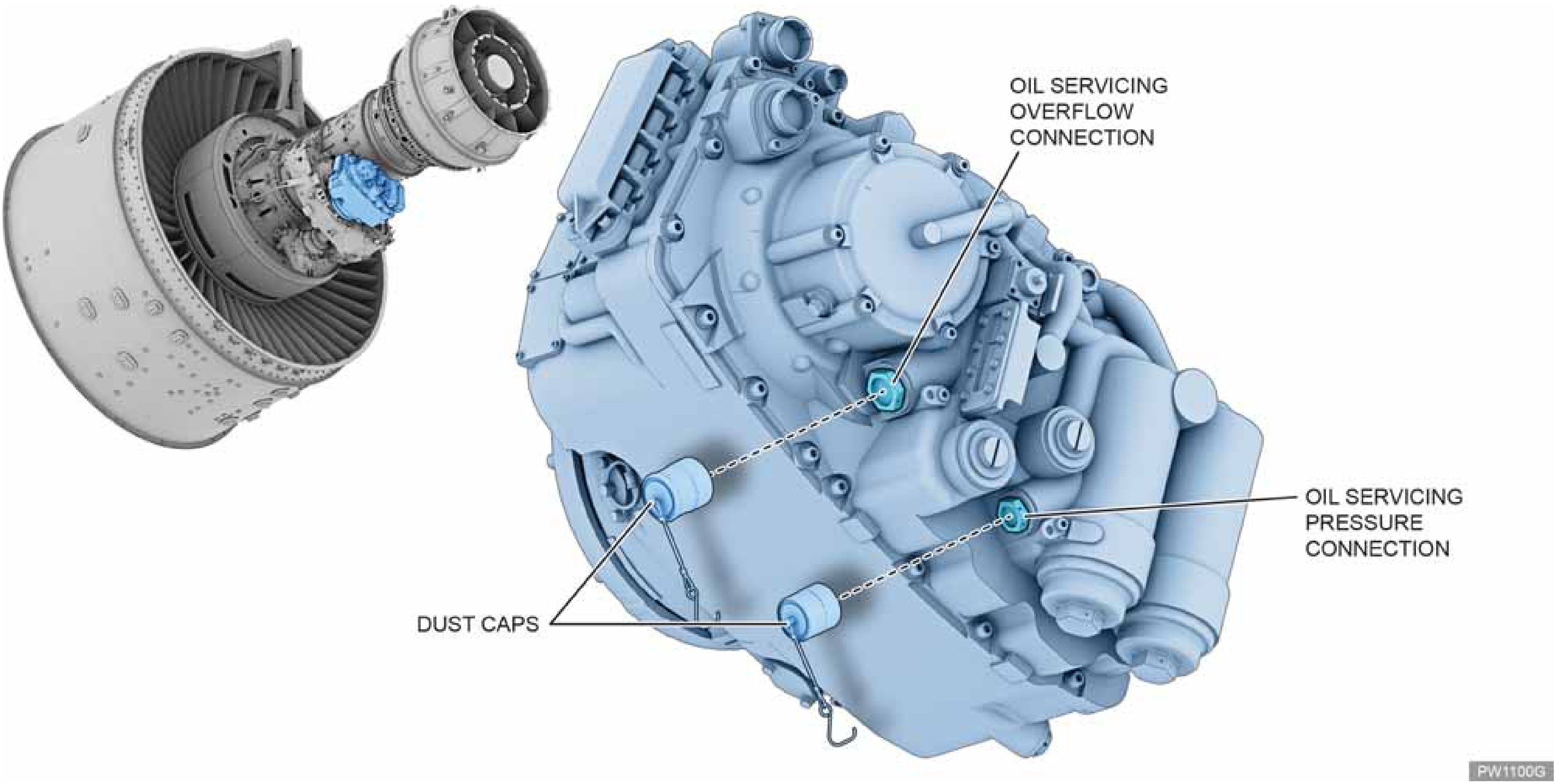
IDG Oil Servicing (Cont.)

4. Disconnect the pressure fill hose.

5. Drain the oil.

6. Disconnect the overflow drain hose.

7. Install the dust caps on the IDG overfill drain and pressure fill valves.



ALTERNATING CURRENT GENERATING SYSTEM – IDG SERVICING (2 OF 2)

ALTERNATING CURRENT GENERATING SYSTEM

IDG Oil Servicing (Cont.)

If the Oil Is Cold

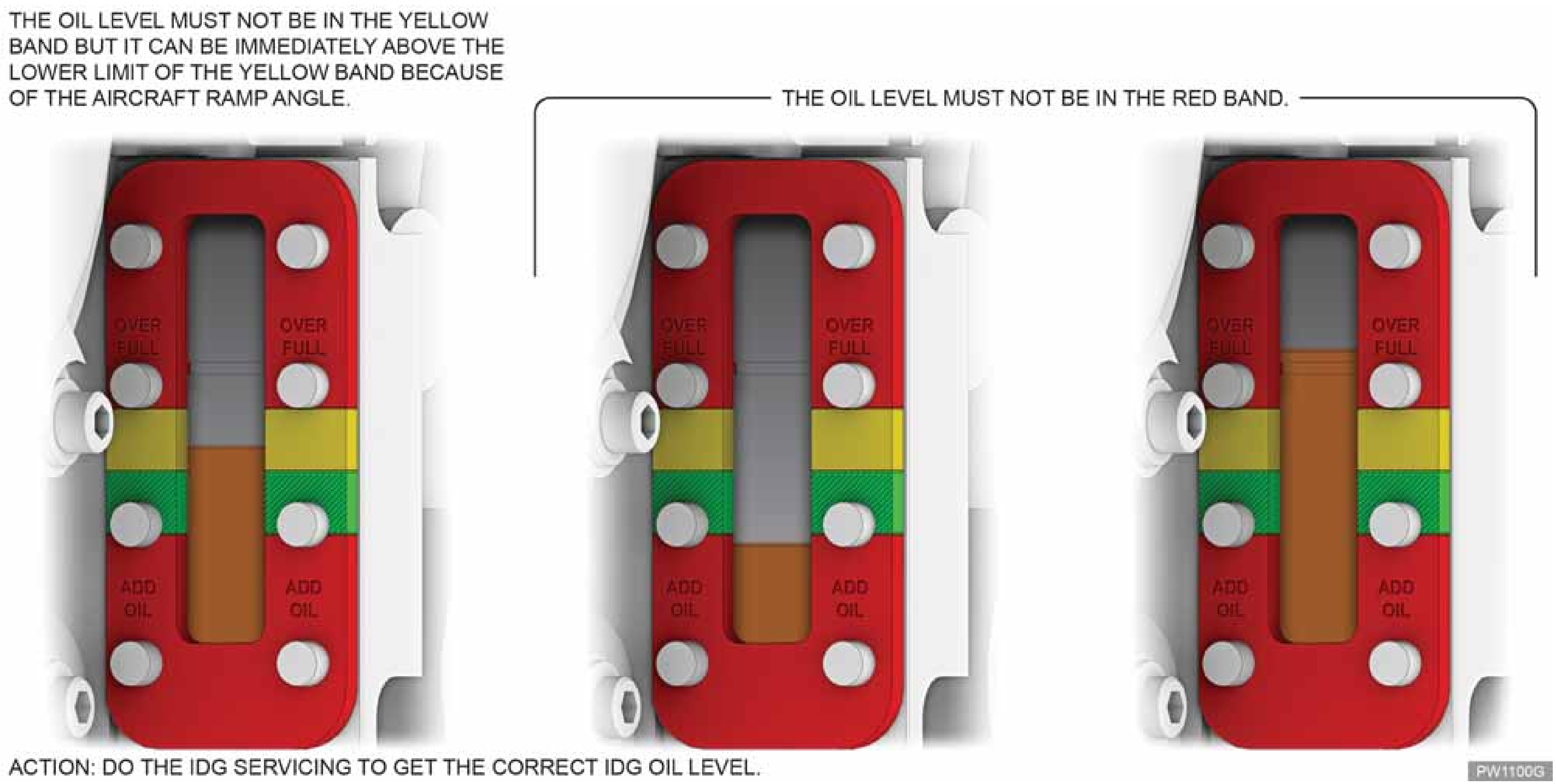
When the oil is cold, servicing requirements are determined by conditions listed below as shown in the sight glass.

- If the oil is immediately above the lower limit of the yellow band because of the aircraft ramp angle, IDG oil draining is not necessary.
- If the oil level is in the yellow band, drain the oil to adjust the oil level.
- If the oil level is below the green band, add oil to adjust the oil level.

If the Oil Is Hot

When the oil is hot, servicing requirements are determined by conditions listed below as shown in the sight glass.

- If the oil level is between the middle of the green band and the top of the yellow band, servicing is not necessary
- If the oil level is below the middle of the green band, add oil to adjust he oil level.
- If the oil level is above the yellow band, drain the oil to adjust the oil level.



ALTERNATING CURRENT GENERATING SYSTEM – IDG OIL SIGHT GLASS

FIRE PROTECTION SYSTEM

The aircraft Fire Protection System actively protects areas at risk by detecting, localizing, and quickly neutralizing the fire.

The Fire Protection System has two subsystems shown below.

Fire Detection

Fire Detection alerts the crew of fire and overheat conditions in these compartments: engine core, APU, avionics, passenger/crew and cargo. Hot air ducts are included as well.

Five electro-pneumatic detection loops located on the pylon, Main Gearbox (MGB) and engine P-flange send signals to the Fire Detection Unit (FDU). Each engine has one FDU, located in the aircraft avionics compartment.

Fire Extinguishing

Fire Extinguishing in the engine core compartment consists of three fire extinguisher nozzles. All three nozzles are supplied by two fire extinguisher bottles located within the pylon. Each engine is serviced by two extinguisher bottles.

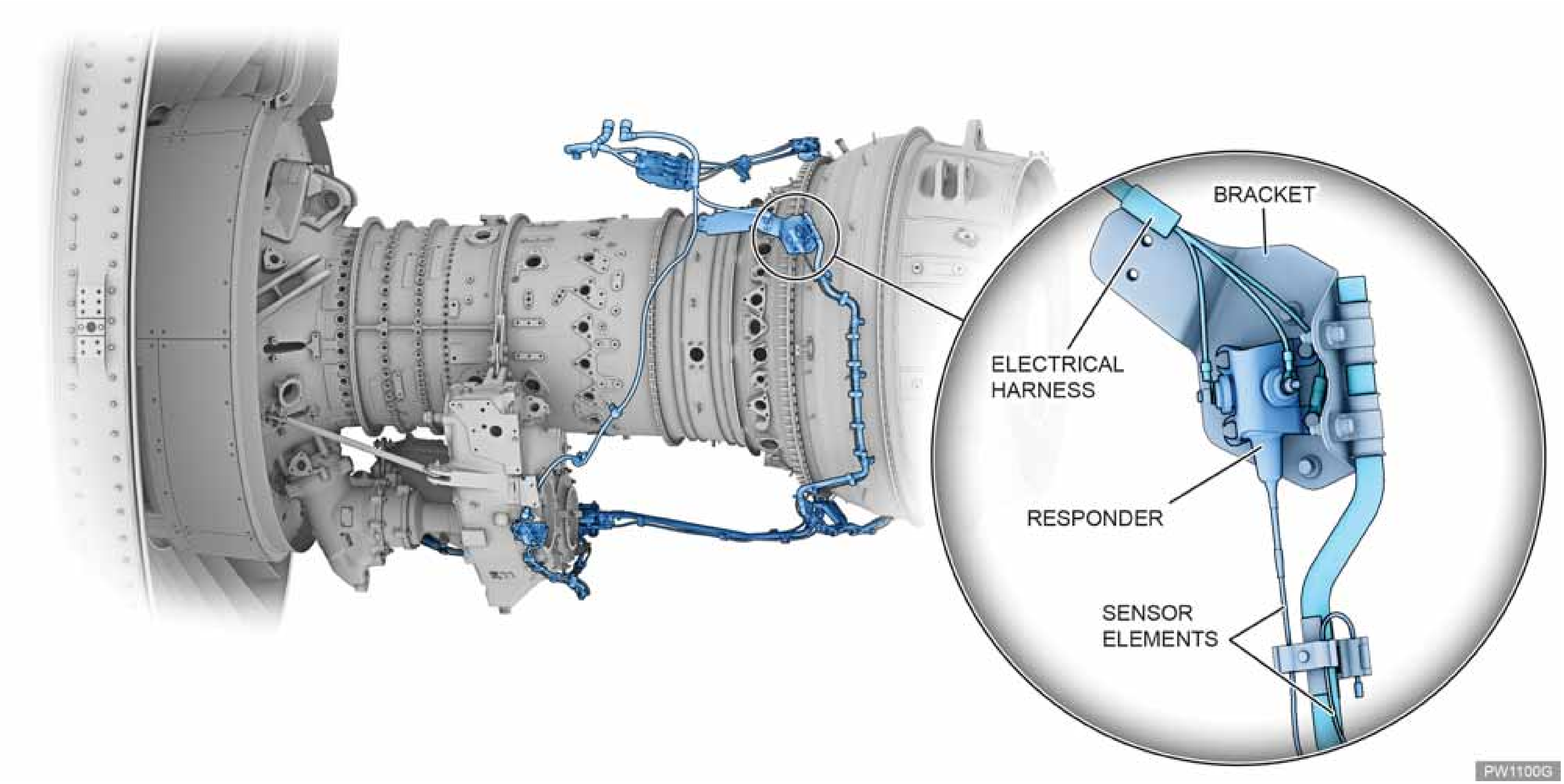
Two of the nozzles direct extinguishing gas at the front of the core compartment. A third nozzle delivers extinguishing gas toward the IDG.

Safety Conditions

CAUTION

DO NOT USE DRY CHEMICAL FIRE EXTINGUISHING AGENTS UNLESS THERE IS AN EMERGENCY. DRY CHEMICAL FIRE EXTINGUISHING AGENTS CAN CAUSE CORROSION OF THE ENGINE GASPATH PARTS.

DO NOT USE WATER TO REMOVE DRY CHEMICAL FIRE EXTINGUISHING AGENTS FROM THE ENGINE. WATER WILL CAUSE THE DRY CHEMICAL FIRE EXTINGUISHING AGENTS TO BOND TO THE AIRFOILS AND CAUSE INCREASED CORROSION OF ENGINE PARTS.



FIRE DETECTION – LEFT SIDE

FIRE PROTECTION SYSTEM (Cont.)

Fire Detection Loops

Purpose:

Fire detection loops sense the ignition of fire within the engine core compartment.

Location:

Four detection loops are mounted on the engine: on either side of the MGB and two on P-flange on either side of the engine. A fifth fire detection loop is mounted off the pylon.

Description:

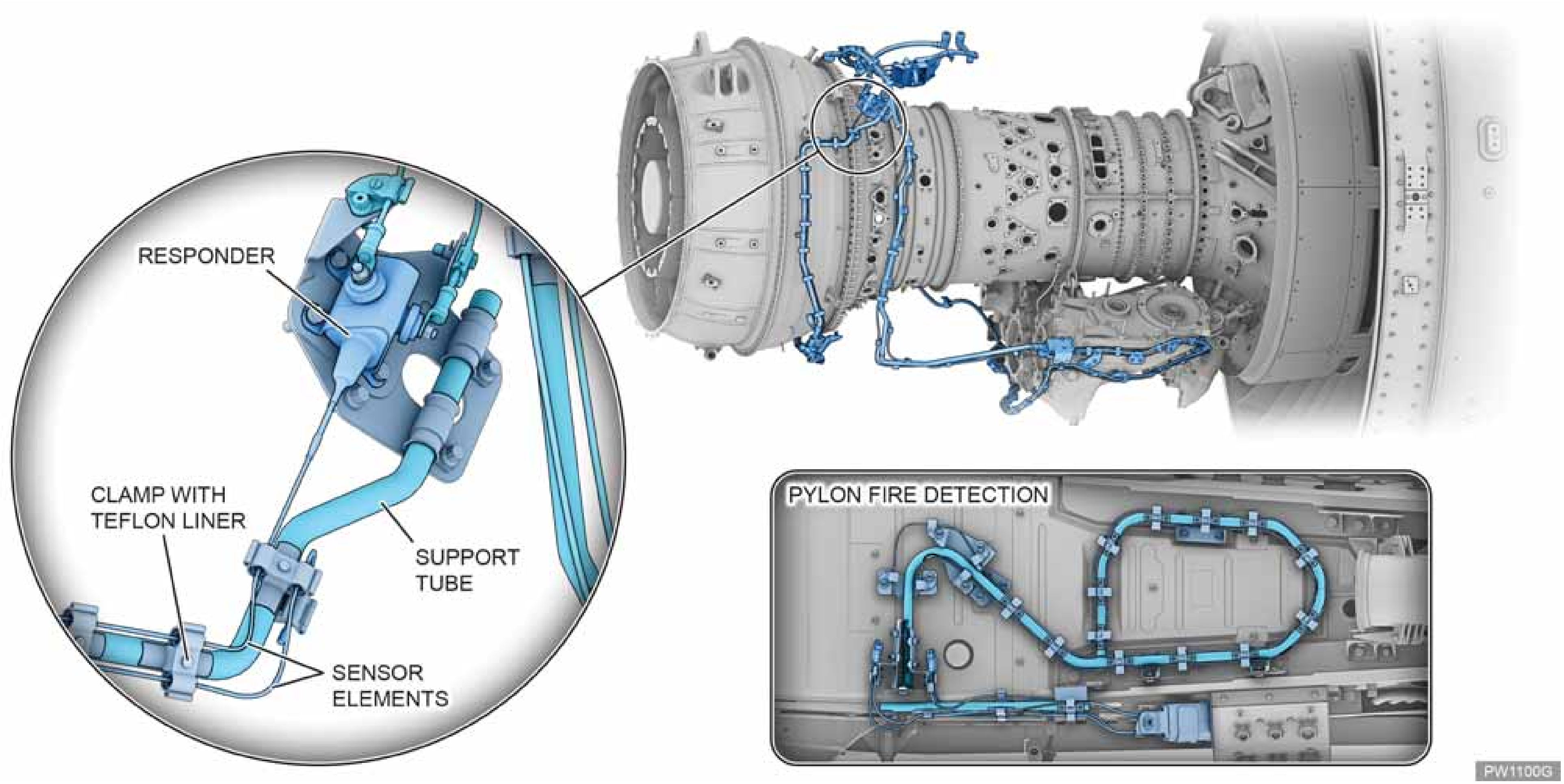
Each fire detection loop consists of a thin, gas-filled tube supported by a larger metal support tube. The gas-filled tube is connected to a responder. The responder contains switches that respond to both the presence of heat on the wire and the loss of gas pressure.

Operation:

The thin tubes of the detection loops contain helium gas surrounding a metal core. The metal core has the ability to store and release hydrogen gas. Under normal conditions, hydrogen is stored within the metal core. When a fire heats the tube, the hydrogen is released from the core, which increases gas pressure in the tube and responder. The responder then sends a signal to the Fire Detection Unit (FDU) within the avionics compartment.

As the tube cools, the hydrogen gas returns to the metal core. In this way, an undamaged fire detector loop can reset itself.

If there is a leak in the tube, the responder detects the loss in gas pressure and sends a signal to the FDU.



FIRE DETECTION – RIGHT SIDE

FIRE PROTECTION SYSTEM (Cont.)

Responder

The responder contains two switches that are activated by gas pressure within the detector loop.

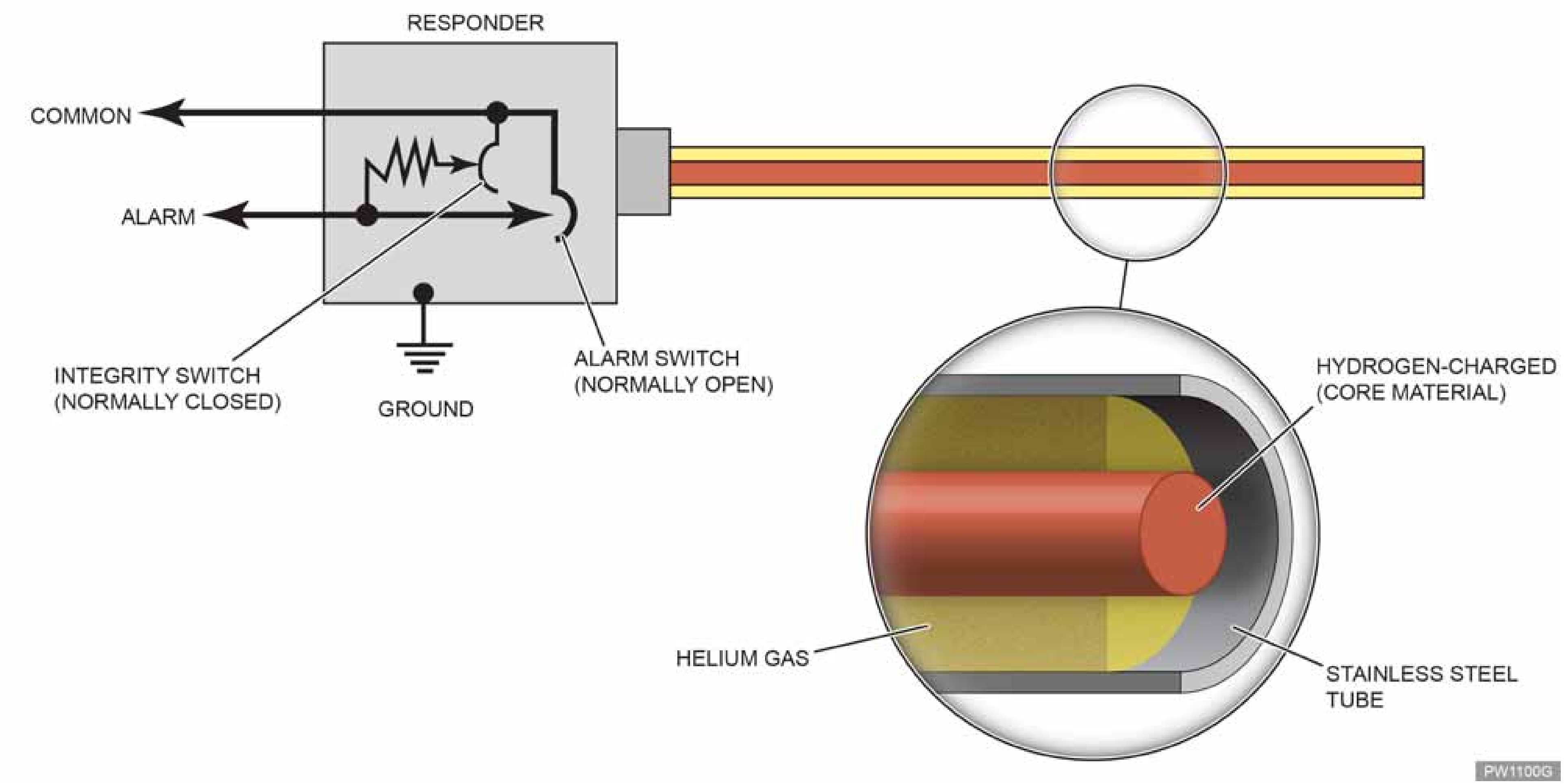
- An alarm switch detects the presence of heat on the loop.
- An integrity switch detects the loss of gas pressure.

Under normal conditions, helium gas pressure within the detection loop keeps the alarm switch open and the integrity switch closed. The gas pressure is set by the manufacturer and cannot be adjusted.

When the detection loop heats up during a fire, the metal core releases hydrogen gas. This action increases gas pressure within the loop and the responder, causing the alarm switch to close.

If the detection loop experiences a leak, the loss of gas pressure in the responder causes the integrity switch to open.

The Fire Detector Unit (FDU) receives the signals from both switches and uses a logic table to determine whether a fire is occurring.



FIRE DETECTION – RESPONDER SWITCHES

FIRE PROTECTION SYSTEM (Cont.)

Fire Extinguishing

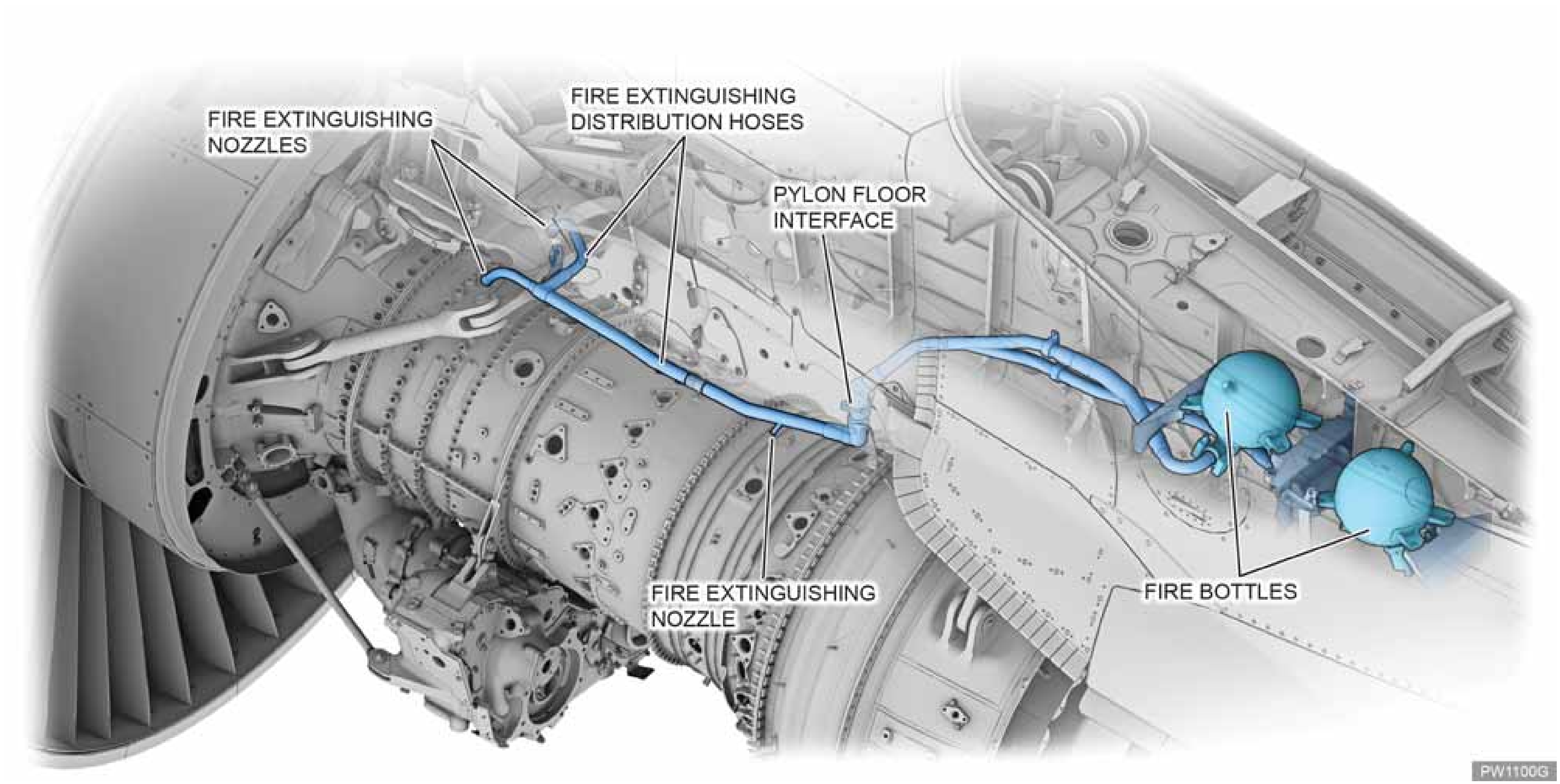
Each engine has a dedicated fire extinguishing system controlled from the cockpit. The system consists of two fire extinguisher bottles installed within the pylon and three fire extinguisher nozzles mounted off the pylon.

Two of the fire extinguishing nozzles are directed toward the front of the engine core compartment. A third nozzle is directed toward the IDG. Halon gas from the nozzles floods the core engine compartment to extinguish any flame. Normal core compartment ventilation will exhaust the gas eventually.

When a fire is detected by the FDU, the MASTER WARN light illuminates in the cockpit, and a Continuous Repetitive Chime (CRC) sounds. In addition, the ENG/FIRE/FAULT indicator illuminates, and the ECAM displays the fire extinguishing procedure.

The fire extinguishing procedure requires the following tasks in the cockpit:

- Throttle control to IDLE
- Turn the ENG/MASTER switch to OFF
- Push ENG/FIRE pushbutton
- Push Agent 1 SQUIB/DISCH pushbutton
- Notify Air Traffic Control (ATC)
- Push Agent 2 SQUIB/DISCH pushbutton after 30 seconds if FIRE warning is still present.



FIRE EXTINGUISHING SYSTEM

HYDRAULIC POWER SYSTEM

The Hydraulic Power System provides the primary hydraulic power source for the aircraft.

Components are listed below.

- Engine-Driven Pump (2) EDP
- Electric pump
- Pump supply line self-sealing disconnect fitting
- Hydraulic filter
- Hydraulic hoses (supply, pressure, case drain)

The aircraft has three pumps: one on each engine and a third on the airframe as a backup in case the other two lose pressure. Each system is a different color for ease of maintenance.

The green system is on the left engine and the yellow is on the right. Each supplies hydraulic pressure when its engine is operating. The blue system on the aircraft has an electric pump that starts automatically when any of the engines operate.

The three system pumps are usually set to operate permanently. If necessary, they pumps can be set OFF from the flight deck.

Safety Conditions

WARNING

DO NOT GET HYDRAULIC FLUID ON YOUR SKIN, IN YOUR EYES, OR IN YOUR MOUTH. HYDRAULIC FLUID IS POISONOUS AND CAN GO THROUGH YOUR SKIN AND INTO YOUR BODY. FLUSH HYDRAULIC FLUID FROM YOUR EYES, MOUTH, OR SKIN WITH WATER. GET MEDICAL AID IF YOU GET HYDRAULIC FLUID IN YOUR EYES OR MOUTH.

CAUTION

DO NOT LET HYDRAULIC FLUID SPILL ON THE ENGINE. YOU MUST IMMEDIATELY REMOVE HYDRAULIC FLUID TO PREVENT DAMAGE TO ENGINE PARTS.

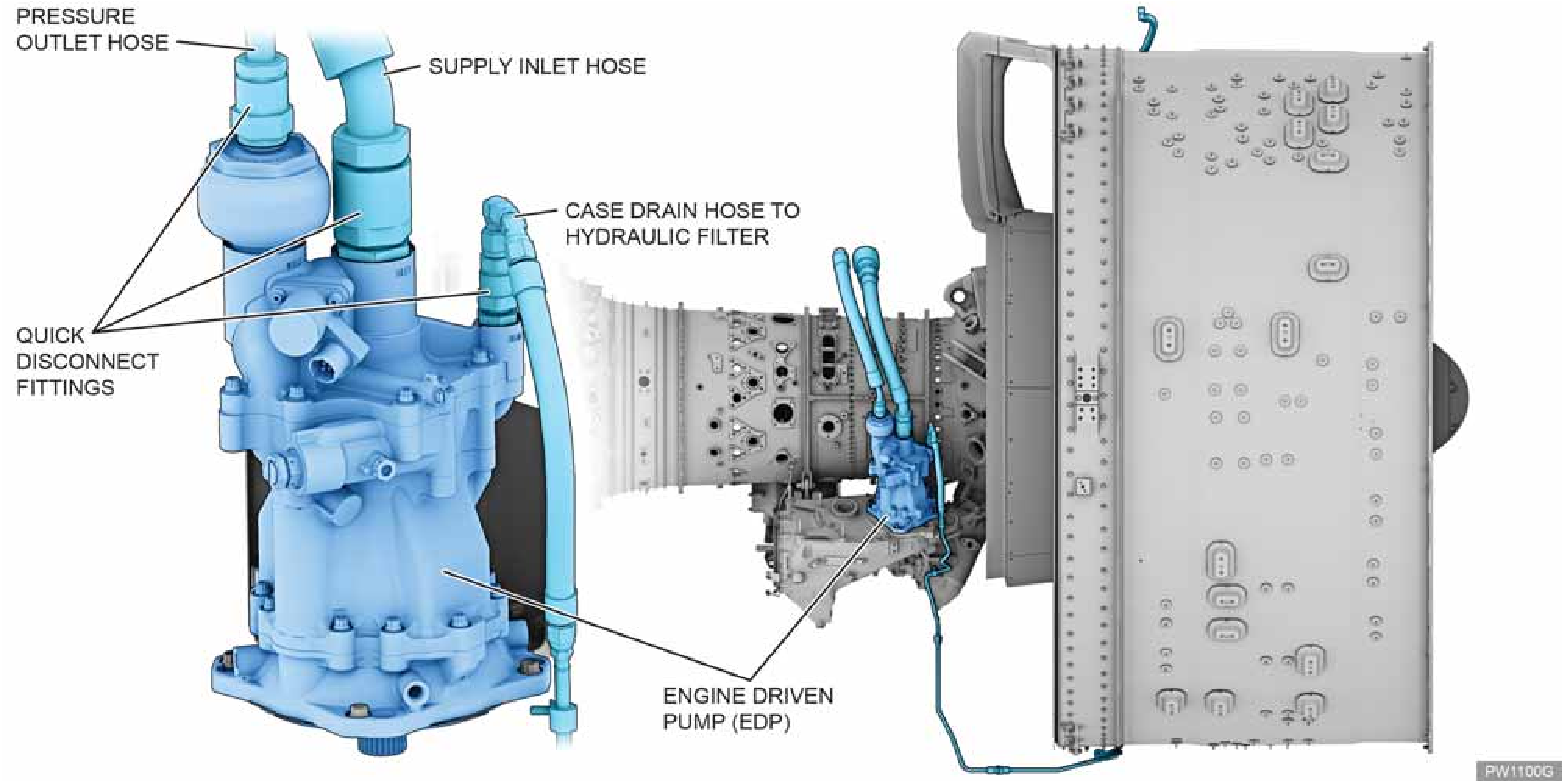
YOU MUST USE A SECOND WRENCH TO HOLD THE MATING PARTS WHEN LOOSEN OR TIGHTEN THE TUBE NUTS. IF YOU DO NOT OBEY THIS CAUTION, YOU CAN TWIST OR DAMAGE THE TUBES.

The variable-displacement Engine-Driven Pump (EDP) is attached to the Main Gearbox on the right side of the engine. A splined quill drive connects the MGB to the input shaft of the pump.

A hydraulic damper on the EDP is designed to dampen ripples from the output to minimize effects on pylon hardware. If the pump fails to provide sufficient output pressure, the system will send an electrical signal to the ECAM display.

The hydraulic filter is installed on the left side of the fan case at 10:00.

For ease of maintenance, hydraulic hoses are equipped with quick-disconnect fittings, and the fittings are covered with a fire sleeve that slips on and off.



HYDRAULIC POWER SYSTEM

HYDRAULIC POWER SYSTEM (Cont.)

Case Drain Filter

Purpose: LRU PMT

The case drain filter removes contaminants from the EDP case drain return to the hydraulic low pressure system.

Location:

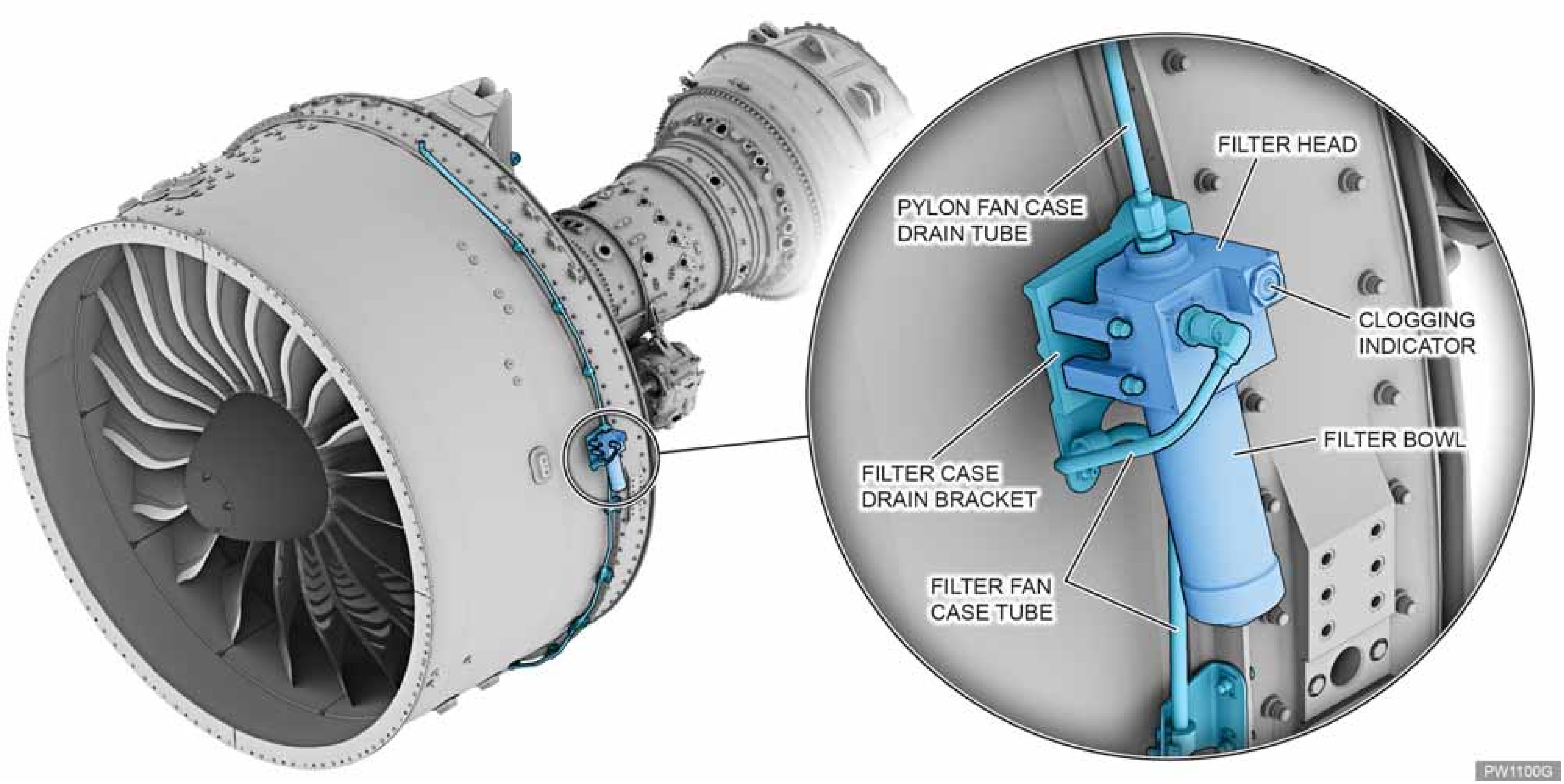
The case drain filter is located on the fan case at 10:00.

Description:

The case drain filter has a filtration rating of 15 microns.

The filter does not have a bypass valve to let fluid through if the element becomes clogged.

A red clogging indicator pin pops up when the filter gets too dirty. The pin can be reset by pushing it in. To prevent a false clogging indication, the indicator pin will not operate when the fluid temperature is too low.



HYDRAULIC POWER SYSTEM – CASE DRAIN FILTER

ICE AND RAIN PROTECTION SYSTEM

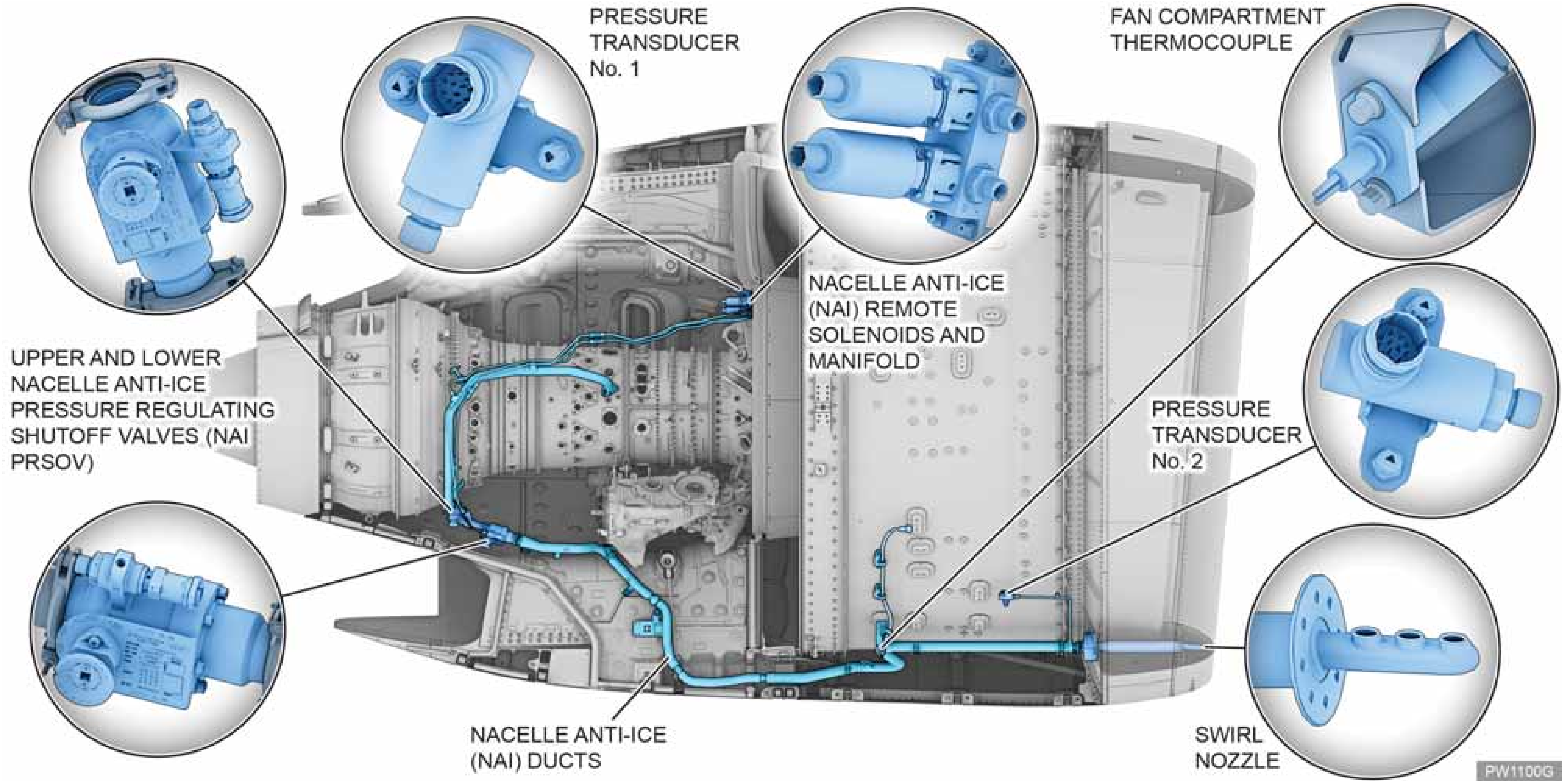
The Ice and Rain Protection System permits aircraft operation without restriction in icy conditions. A subsystem is the Nacelle Anti-Ice (NAI) System, which prevents ice formation on the leading edge of the inlet cowl during aircraft operations.

Nacelle Anti-Ice (NAI) System

System components are located on the right side of the engine. A list of components appears below.

- Nacelle Anti-Ice Pressure Regulating Shutoff Valve (2) NAI PRSOV
- Nacelle Anti-Ice remote solenoid (2) and manifold
- Nacelle Anti-Ice pressure transducer (2)
- Fan compartment thermocouple
- Nacelle Anti-Ice ducts
- Swirl nozzle

The NAI System is selected on/off by the pilot, usually when operating in icing conditions. When selected ON, the system directs 6th Stage High Pressure Compressor (HPC) air to the inlet cowl through a series of NAI ducts.



ENGINE COWL ANTI-ICE SYSTEM

ICE AND RAIN PROTECTION SYSTEM

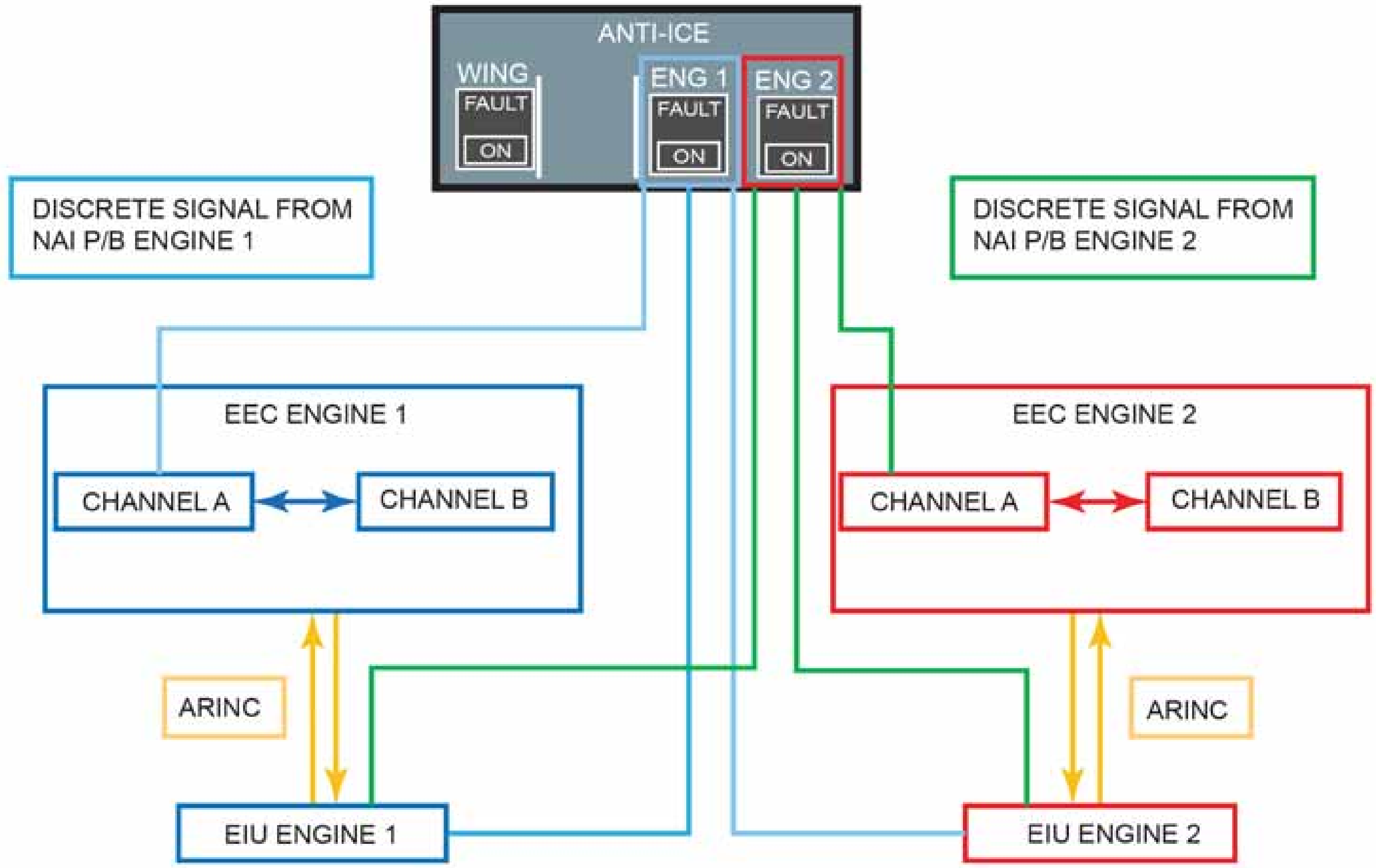
Nacelle Anti-Ice (NAI) System (Cont.)

Controlled by the EEC, the system is manually activated by the pilot on the ground or in flight via the engine NAI cockpit Push Button (P/B). Each engine has its own push button. Each P/B through switch sends the command to each Electronic Interface Unit (EIU). Push buttons have a bulb to warn the crew in case of system malfunction.

Pressure Regulating Shut-Off Valves (PRSOVs) allow the flow of HPC air to the inlet cowl. The signal to activate PRSOVs is sent directly to Channel A of the EEC and to the EIU by a discrete signal from the NAI cockpit P/B. The Channel A signal is then internally transferred to Channel B. The EEC de-energizes the two solenoids that open the PRSOVs and sends a signal to the EIU from both channels, indicating the anti-ice is ON. The EIU then sends this signal to the cockpit.

When anti-ice is selected OFF by the NAI P/B, the EEC again internally transfers the signal to Channel B and energizes the two solenoids to close the PRSOVs. One discrete signal informs the opposite EIU that engine thrust must be computed with NAI activated.

Channel A commands the upper PRSOV solenoid and Channel B commands the lower one. Only one PRSOV is closed at each cycle in order to reduce the number of utilization cycles.



ICE AND RAIN PROTECTION SYSTEM – EEC INTERFACE

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Nacelle Anti-Ice Pressure Regulating Shutoff Valves (NAI PRSOV)

Purpose: LRU PMT

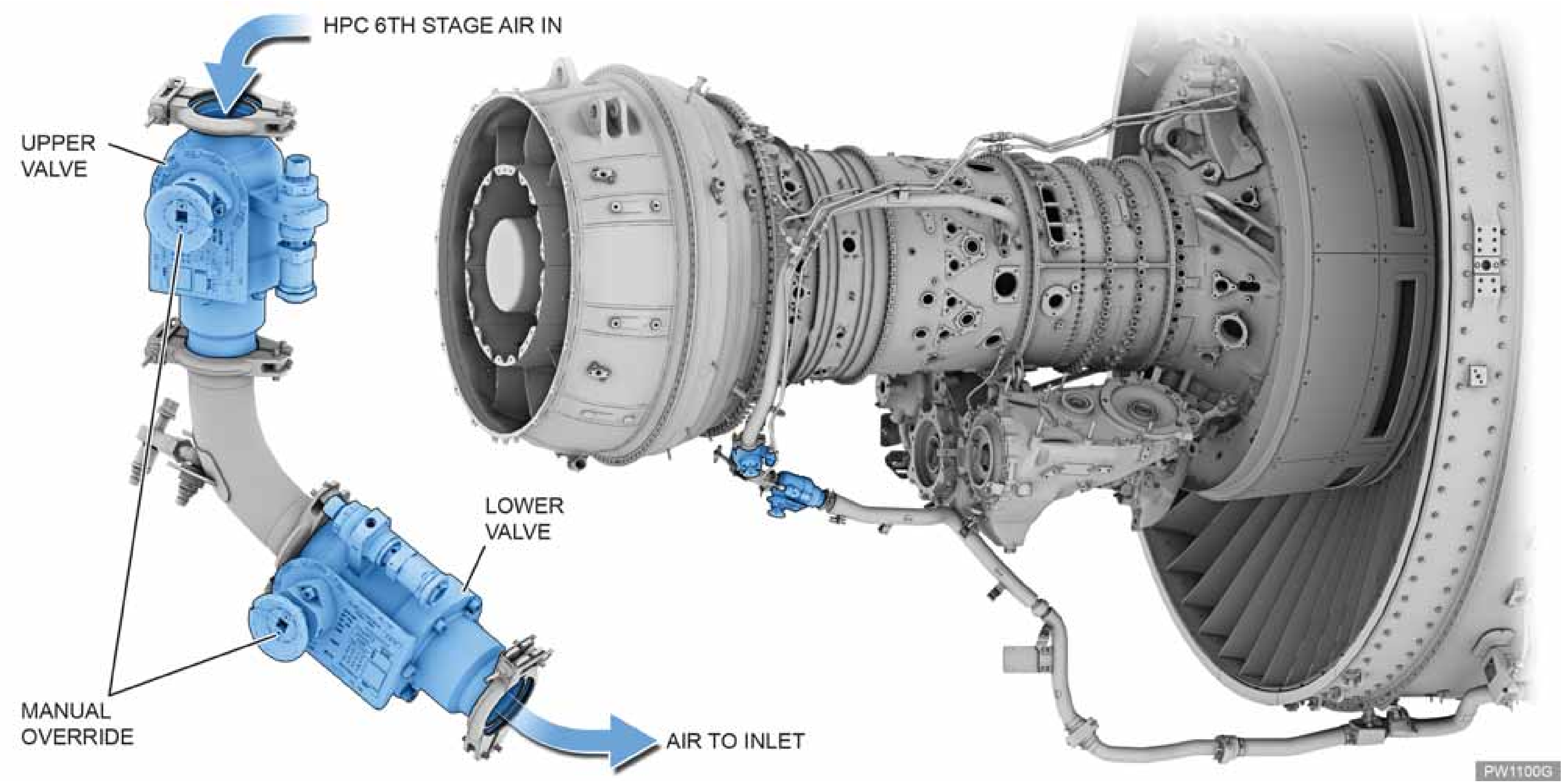
Upper and lower Nacelle Anti Ice Pressure Regulating Shutoff Valves operate in tandem to control pressure and airflow of HPC 6^{th} Stage air used for inlet anti-ice.

Location:

The valves are mounted to the HPC case at 6:00 and 6:30.

Description:

When the NAI solenoids de-energize, HPC 6^{th} Stage air flows through the NAI PRSOVs. When the solenoids energize, the flow of air stops.



ICE AND RAIN PROTECTION SYSTEM – NAI PRESSURE REGULATING SHUTOFF VALVES (1 OF 2)

ICE AND RAIN PROTECTION SYSTEM

Nacelle Anti-Ice Pressure Regulating Shutoff Valves (NAI PRSOV)

Description (Cont.):

A list of hardware is shown below.

- Valve body housing
- Relief valve
- Relief valve spring
- Piston
- Control orifice
- Manual override cam
- Sense line port
- Reference chamber

Operation:

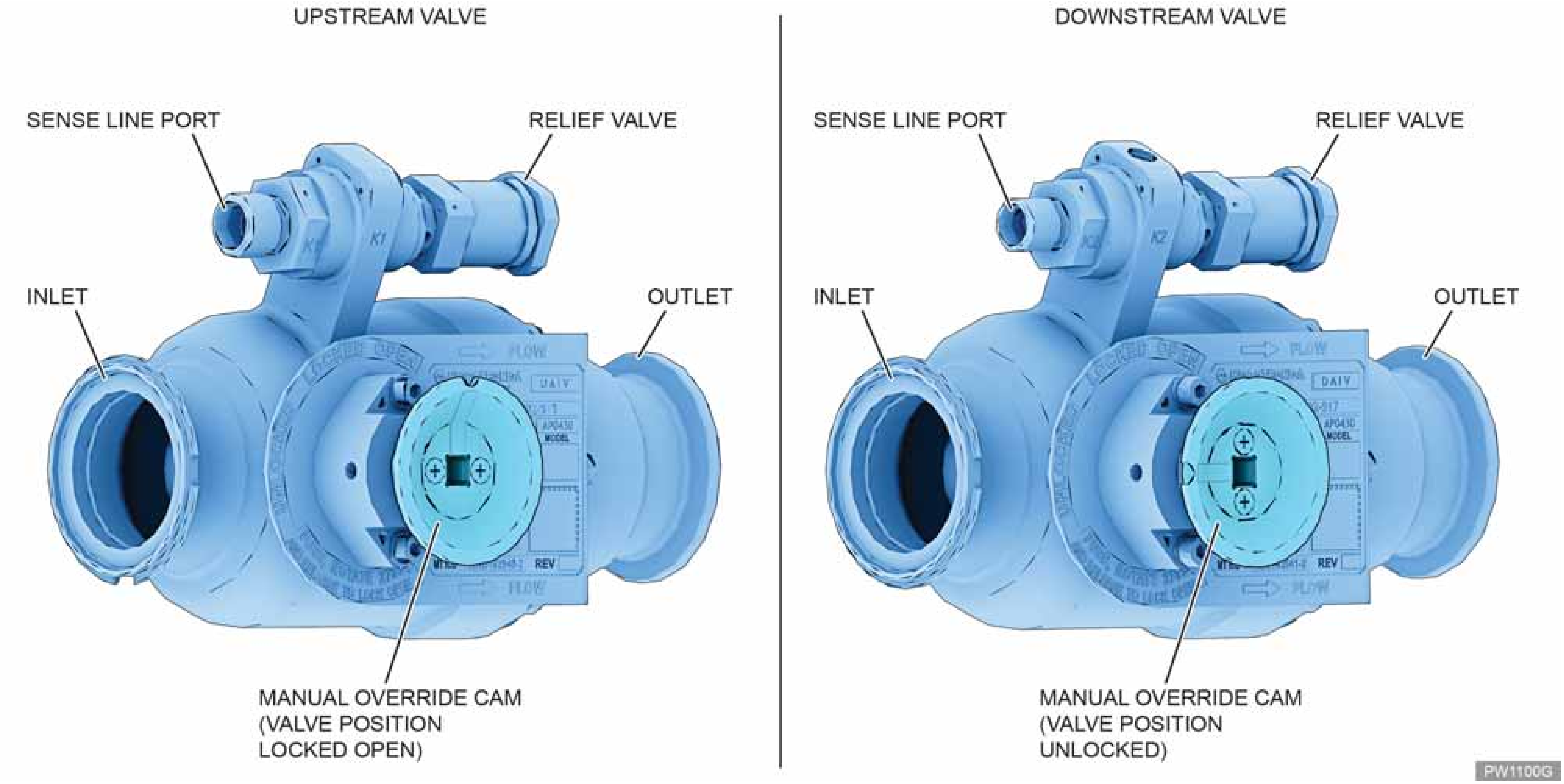
As the NAI solenoid de-energizes, and HPC 6th Stage air fills the reference chamber, the piston is compressed and forced to move to the open position. This allows the HPC 6th Stage air to flow through the PRSOV.

When the NAI solenoid energizes, and HPC 6th Stage air is no longer supplied to the reference chamber, the piston moves to the closed position and the flow of air through the PRSOV stops.

Both upper and lower PRSOVs regulate pressure mechanically. See the chart for more information about working level pressures.

PRSOV	PSIG
Upper	104
Lower	80

Each valve contains a manual override feature that allows the valve to be locked open for Master Minimum Equipment List (MMEL) dispatch. To do this, maintenance personnel access provisions in the Outer Fixed Structure (OFS) of the right thrust reverser door. A 3/8 inch extension through the access port allows the valve to be rotated into the open position.



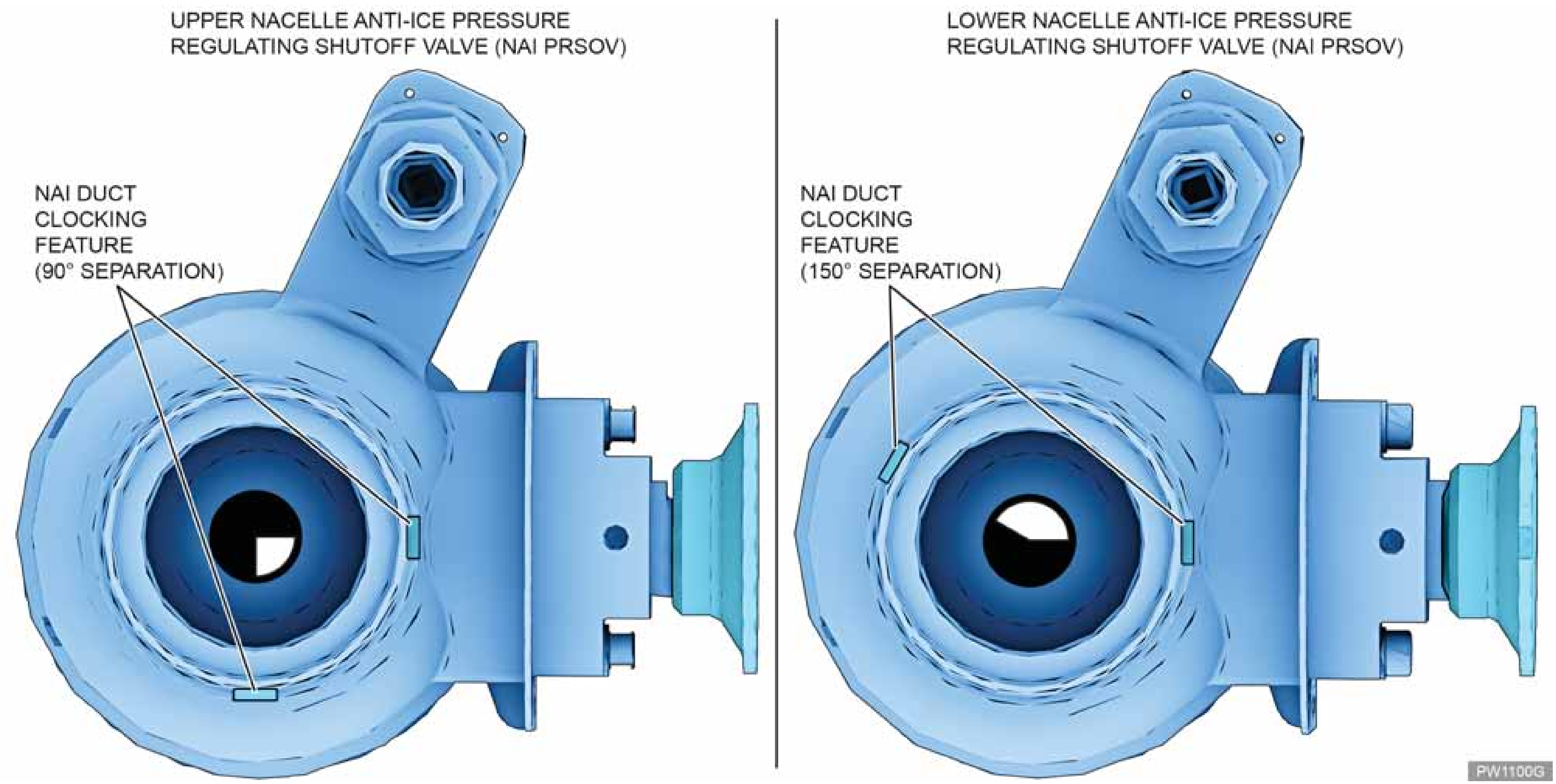
ICE AND RAIN PROTECTION SYSTEM – NAI PRESSURE REGULATING SHUTOFF VALVES (2 OF 2)

ICE AND RAIN PROTECTION SYSTEM

Nacelle Anti-Ice Pressure Regulating Shutoff Valves (NAI PRSOV)

Operation (Cont.):

Upper and lower PRSOVs are not interchangeable due to regulating pressure differences. A valve clocking feature distinguishes the ducts on the upper and lower valve types, preventing incorrect installation.



ICE AND RAIN PROTECTION SYSTEM – NAI DUCT CLOCKING FEATURES

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Nacelle Anti-Ice (NAI) Remote Solenoids and Manifold

Purpose:

LRU PMT

The NAI remote solenoids and manifold control the opening and closing of the NAI upper and lower PRSOVs.

Location:

The remote solenoid manifold is attached to the CIC firewall at 1:00.

Description:

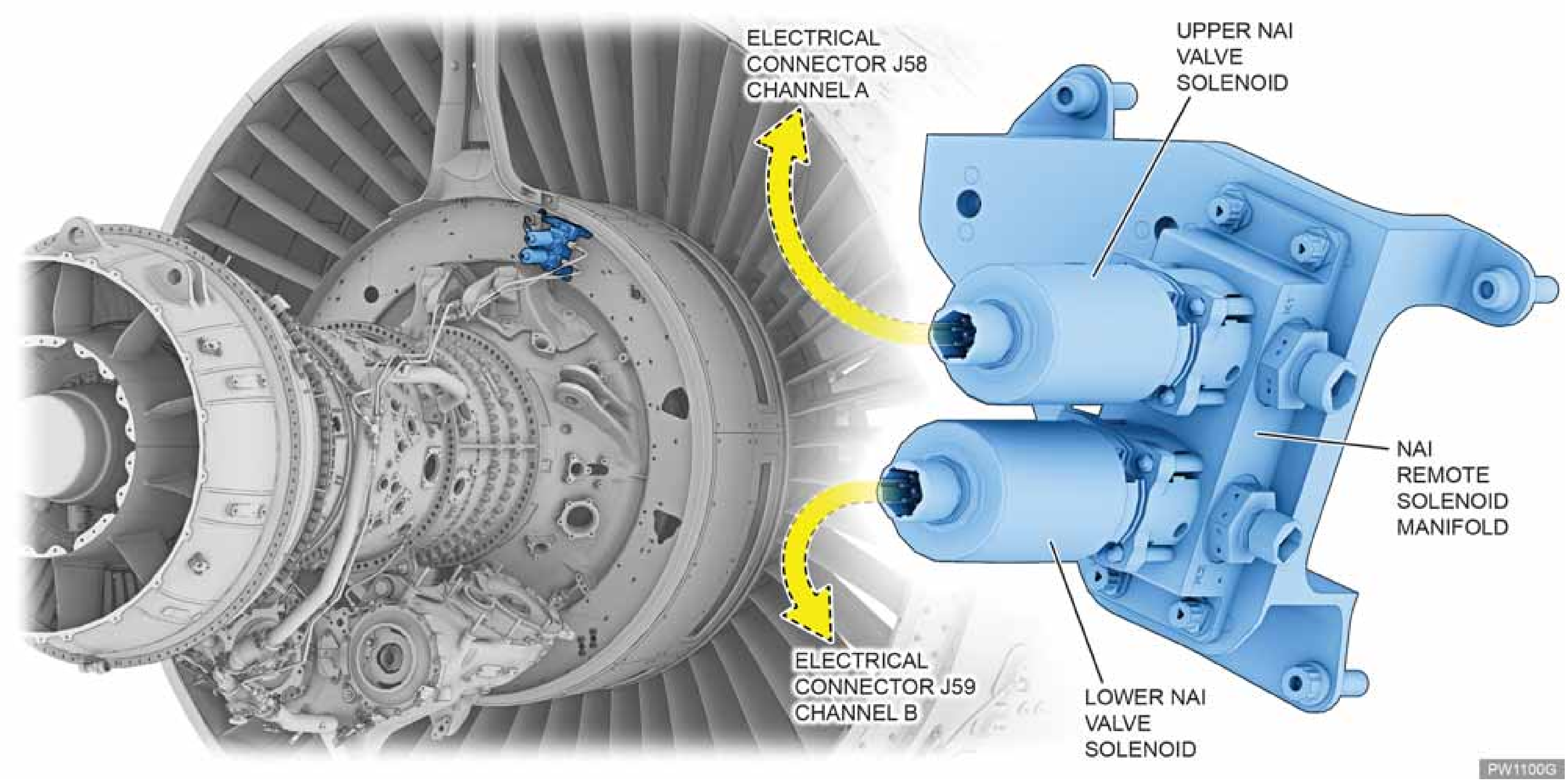
The remote solenoid manifold supports two NAI solenoids. One solenoid is dedicated to the upper PRSOV and the other controls the lower one.

Operation:

Each solenoid is a two-way device controlled by a 28Vdc signal from the EEC. Channel A controls the NAI solenoid for the upper PRSOV, and Channel B controls the lower one.

When the solenoid de-energizes, its inlet port opens, allowing HPC 6th Stage air to pressurize the PRSOV reference chamber. This pushes the PRSOV piston into the open position.

When the solenoid energizes, HPC 6th Stage air pressure is blocked, depressurizing the reference chamber in the PRSOV. This allows the PRSOV piston to return to the closed position and air flow pushes the piston closed.



ICE AND RAIN PROTECTION SYSTEM – NAI REMOTE SOLENOIDS AND MANIFOLD

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Nacelle Anti-Ice (NAI) Pressure Transducers

Purpose:

LRU PMT

NAI pressure transducers monitor NAI duct pressure upstream and downstream of the NAI PRSOVs to determine their operating condition.

Location:

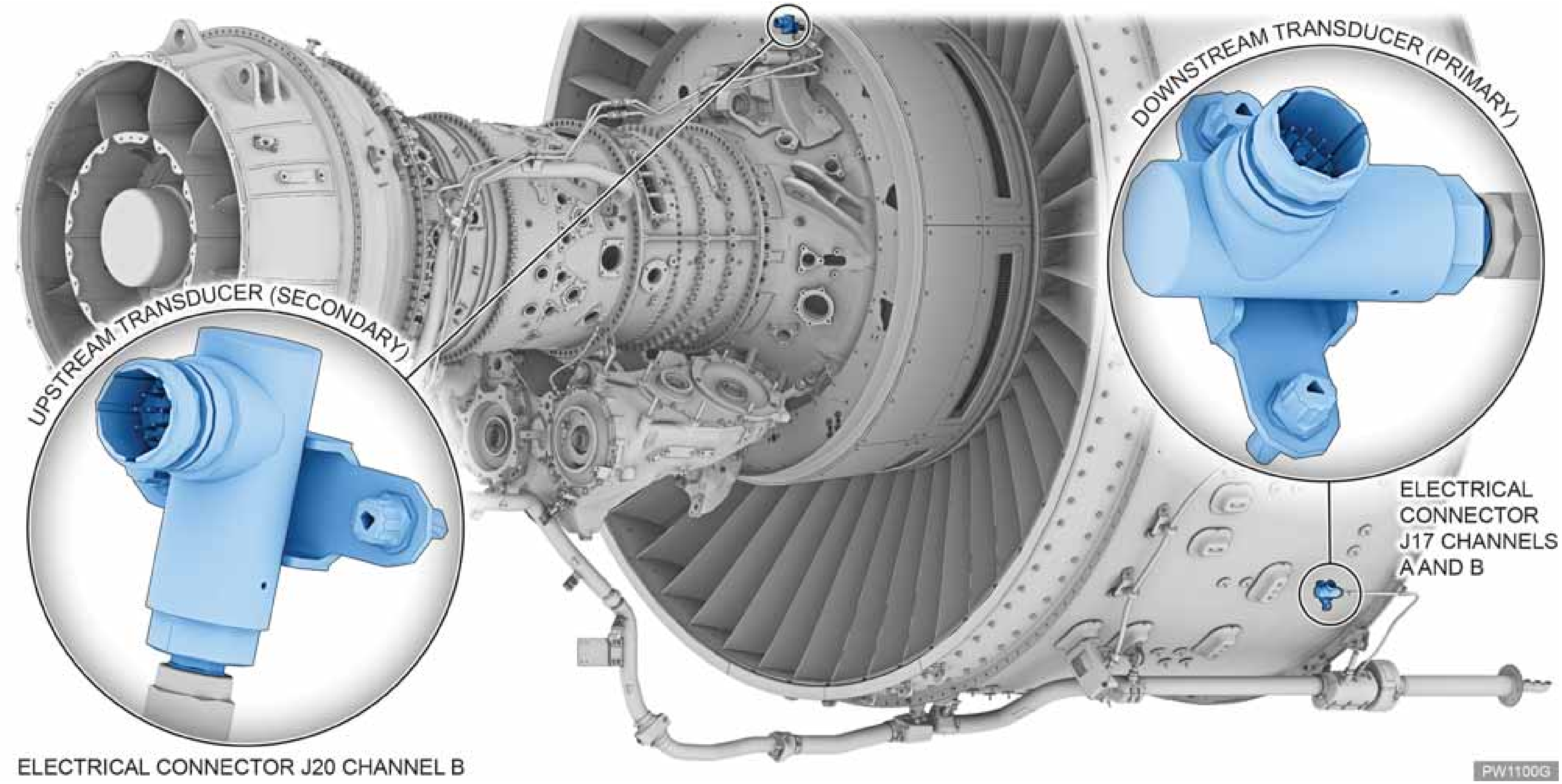
One transducer is located on the remote solenoid bracket mounted to the Compressor Intermediate Case firewall at 1:00. The other transducer is mounted on the fan case at 4:30.

Description:

The downstream pressure transducer is located downstream of the two PRSOVs. As the primary transducer its role is to monitor PRSOV positions. It is a dual-channel transducer and provides a pressure signal to Channel A of the EEC.

The upstream pressure transducer senses pressure from the vent line of the lower PRSOV. Its role is to figure out which PRSOV has failed.

It is a single-channel transducer and provides a pressure signal to Channel B of the EEC.



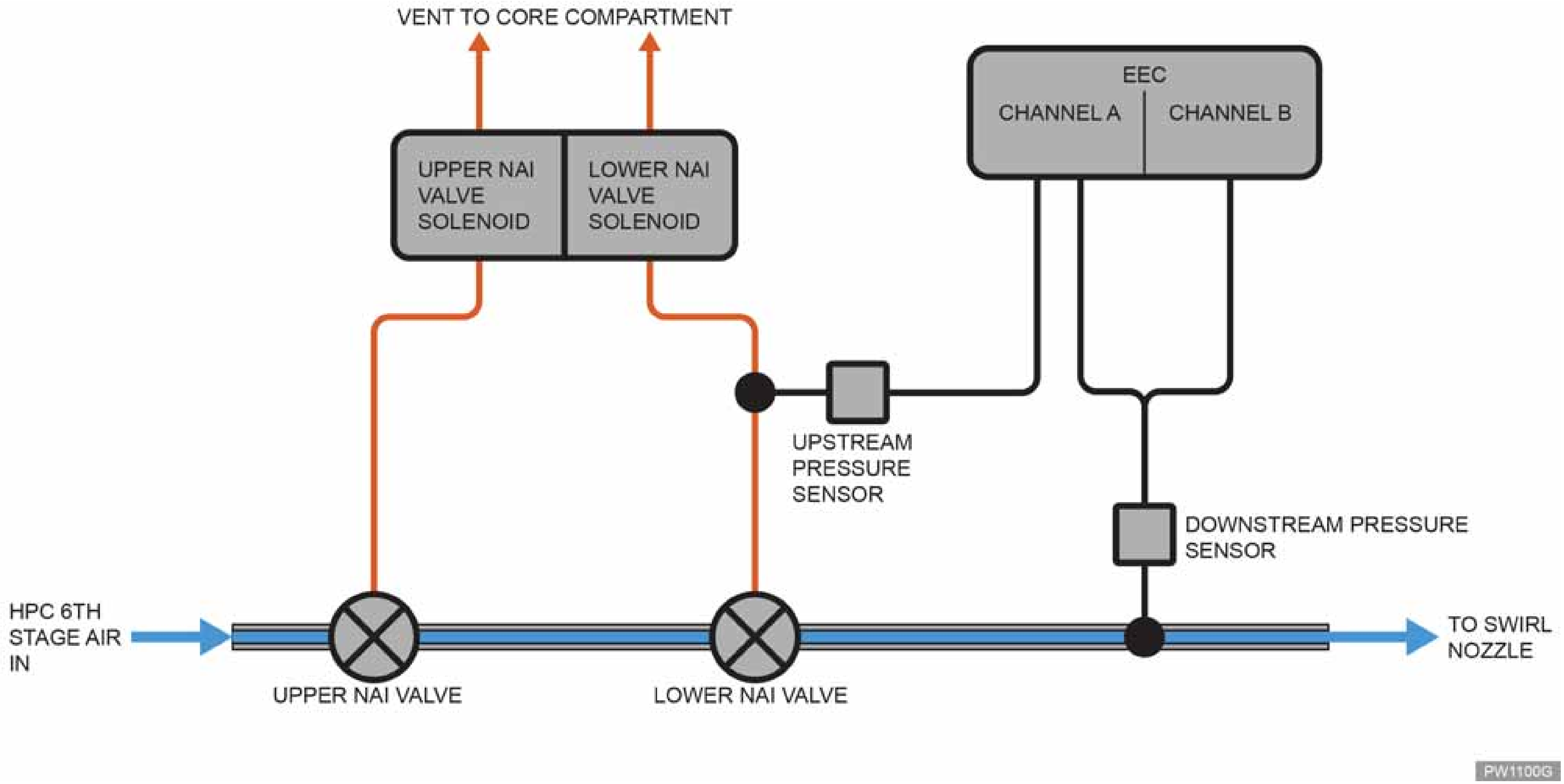
ICE AND RAIN PROTECTION SYSTEM – NAI PRESSURE TRANSDUCERS

ICE AND RAIN PROTECTION SYSTEM

Nacelle Anti-Ice (NAI) Pressure Transducers (Cont.)

Operation:

The EEC uses the average of the two pressure signals from the downstream pressure transducer when both signals are valid. Each EEC channel is able to use the other channel's pressure signal in case of single-signal failure. If both signals are invalid, the EEC will use the last "good" value.



ICE AND RAIN PROTECTION SYSTEM – NAI PRESSURE TRANSDUCER OPERATION

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Fan Compartment Thermocouples

Purpose:

LRU PMT

Fan compartment thermocouples detect hot air leakage of the NAI System in the fan compartment.

Location:

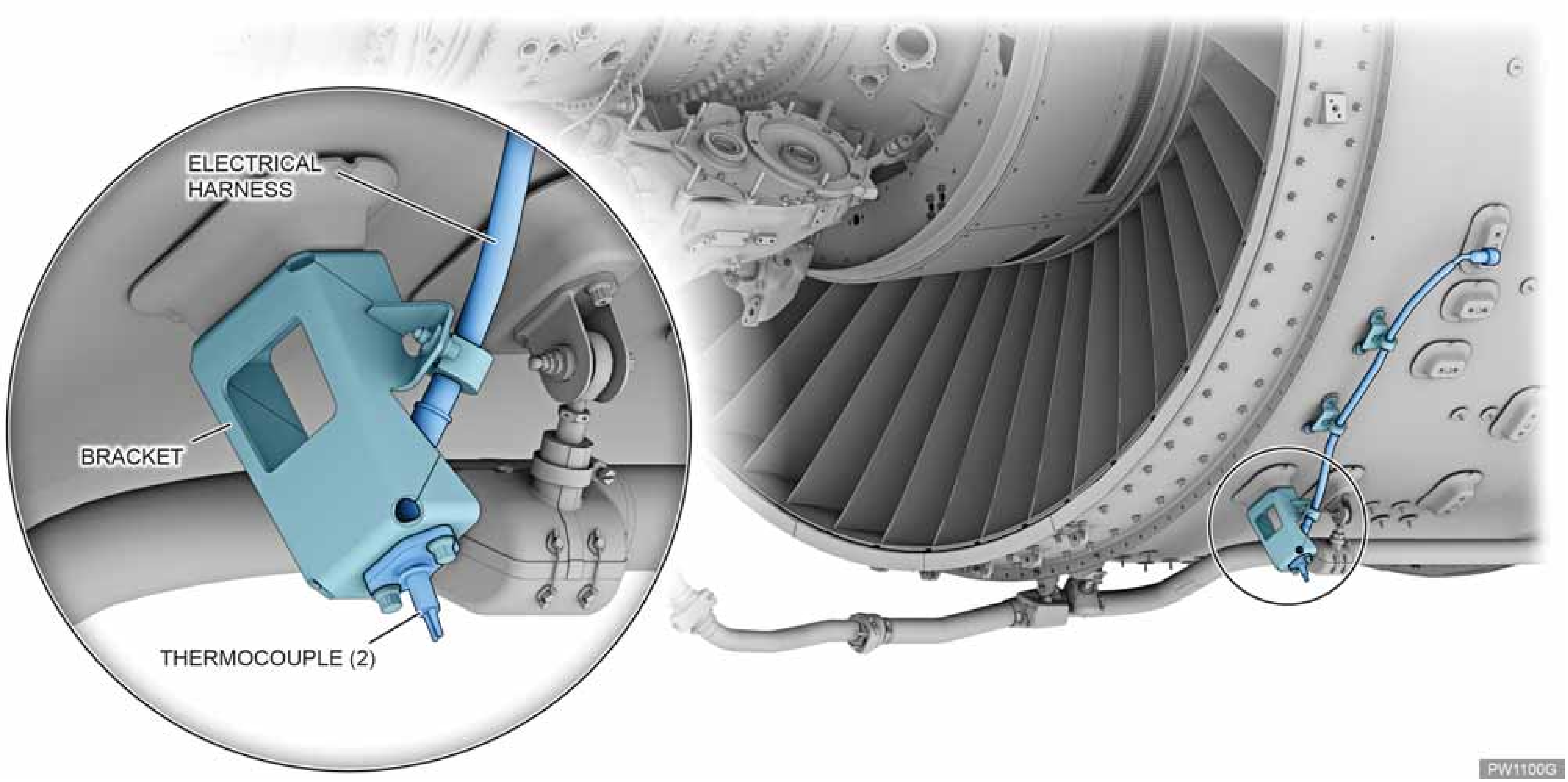
The two thermocouples are located in the fan case and mounted to a connection plate at 5:00.

Description:

The two Type K thermocouples, one for each EEC channel, are mounted in series with two RTDs that are used as Cold Junction Compensation (CJC). The thermocouples provide the EEC with temperature measurement in the fan compartment.

Operation:

The EEC uses the average of the two temperature signals when both signals are valid. Each EEC channel is able to use the other channel's thermocouple signal or RTD signal in case of single-signal failure. If both signals are invalid, the EEC is unable to detect a hot air leakage event.



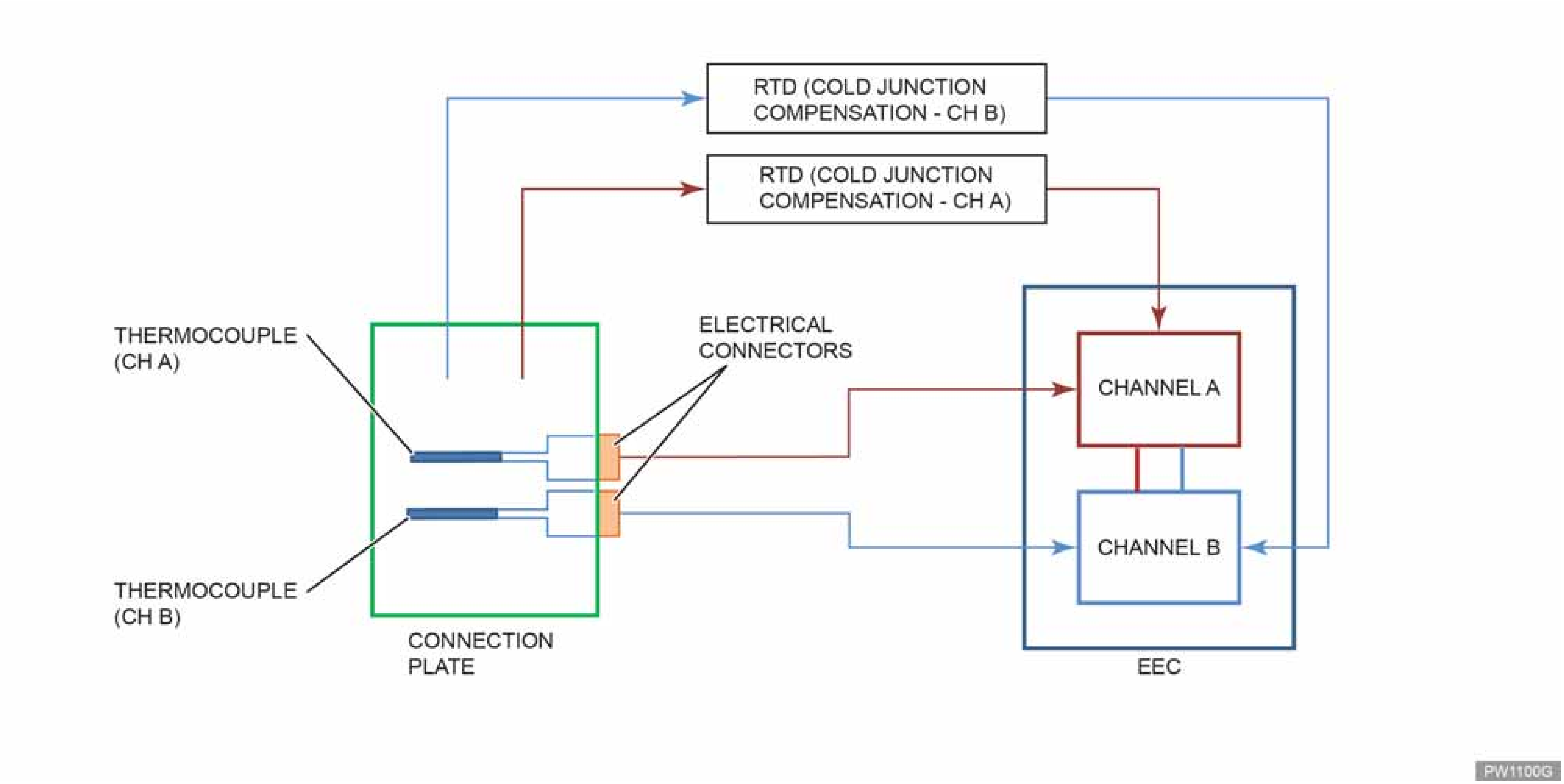
ICE AND RAIN PROTECTION SYSTEM – FAN COMPARTMENT THERMOCOUPLES

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Fan Compartment Thermocouples

Operation (Cont.):

When the temperature in the fan compartment exceeds a given value on either EEC channel, each channel will detect a hot air leakage event. Once the event has been detected, the EEC powers both solenoids to close the two PRSOVs.



ICE AND RAIN PROTECTION SYSTEM – FAN COMPARTMENT THERMOCOUPLE OPERATION

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Nacelle Anti-Ice (NAI) Ducts

Purpose: LRU PMT

The NAI ducts supply hot HPC 6th Stage air to the inlet cowl forward lip to prevent ice buildup.

Location:

The ducts are located on the right side of the engine, leading from the diffuser case at 2:30 rearward, to the low turbine, down to the bifurcation wall at 6:00 and into the rear of the inlet cowl at 5:00.

Description:

Ducting is segmented into four sections that route hot air from the High Pressure Compressor 6th Stage bleed port to the inlet swirl nozzle interface. See the chart for duct diameter measurements.

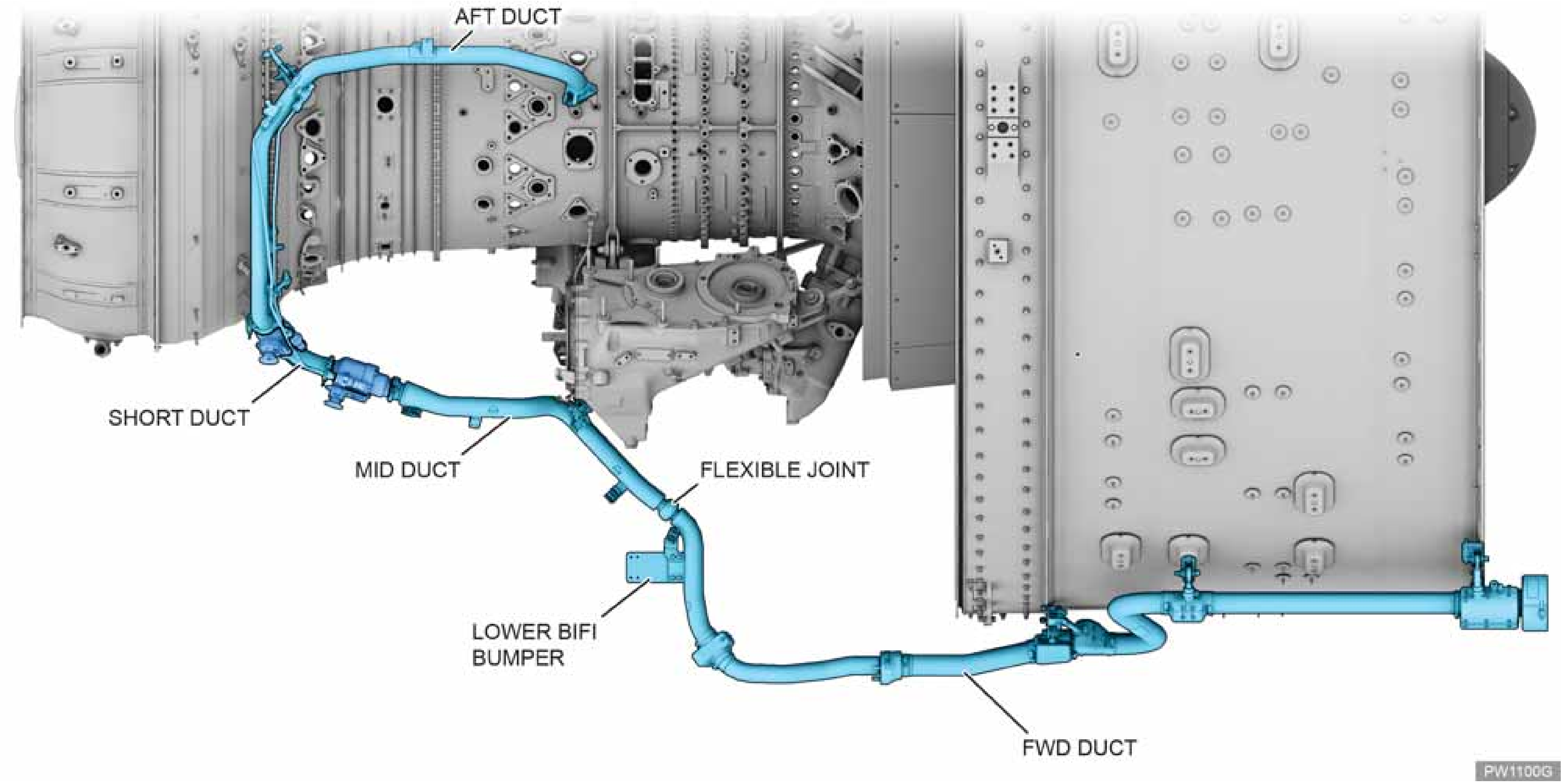
Operation:

The MID and FWD ducts have insulation along the entire length of the duct. The MID duct incorporates a flexible joint that allows for thermal expansion during operation.

In addition it has a lower Bifurcation (BiFi) bumper that provides lateral restraint thermal expansion of the duct and maintains clearances between BiFi walls.

Ducting is secured throughout the routing by links attached to the engine case and to V-Band clamps.

<table>
<tr><th>Duct</th><th>Diameter</th></tr>
<tr><td>AFT</td><td rowspan="3">1.5 in.</td></tr>
<tr><td>Short</td></tr>
<tr><td>MID</td></tr>
<tr><td>FWD</td><td>1.5 in. tapering to 1 in.</td></tr>
</table>



ICE AND RAIN PROTECTION SYSTEM – NAI DUCTS

ICE AND RAIN PROTECTION SYSTEM (Cont.)

Swirl Nozzle

Purpose:

PMT

The swirl nozzle delivers HPC 6th Stage air controlled by the NAI System to prevent ice buildup in the inlet cowl.

Location:

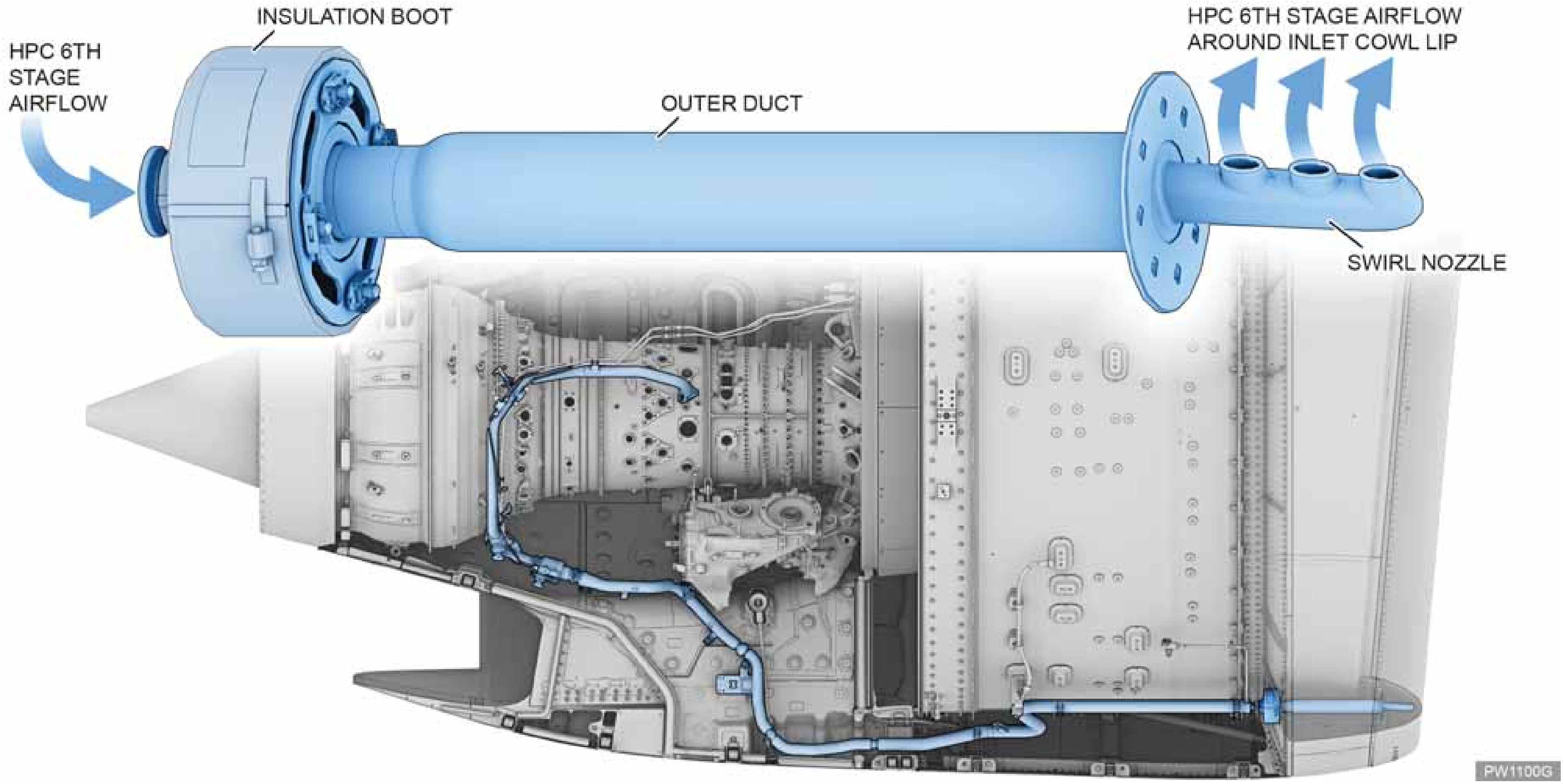
The nozzle is attached to the rear of the inlet cowl at 5:00.

Description:

The swirl nozzle is a dual-walled duct that provides the path for the system to inject a small amount of hot, high-pressure air through a convergent nozzle.

Operation:

The air traveling through the nozzle is sent tangentially into the nose lip of the inlet cowl.



ICE AND RAIN PROTECTION SYSTEM – SWIRL NOZZLE

PNEUMATIC SYSTEM

The Pneumatic System supplies regulated, hot, high-pressure air to the aircraft for cabin pressurization and air conditioning; wing anti-ice; cargo hold heating; water tank and hydraulic reservoir pressurization; and starting the opposite engine.

The system consists of the components below.

- Ducting
- High Pressure Shutoff Valve HPSOV
- Pressure Regulating and Shutoff Valve PRSOV
- Intermediate Pressure Check Valve IPCKV

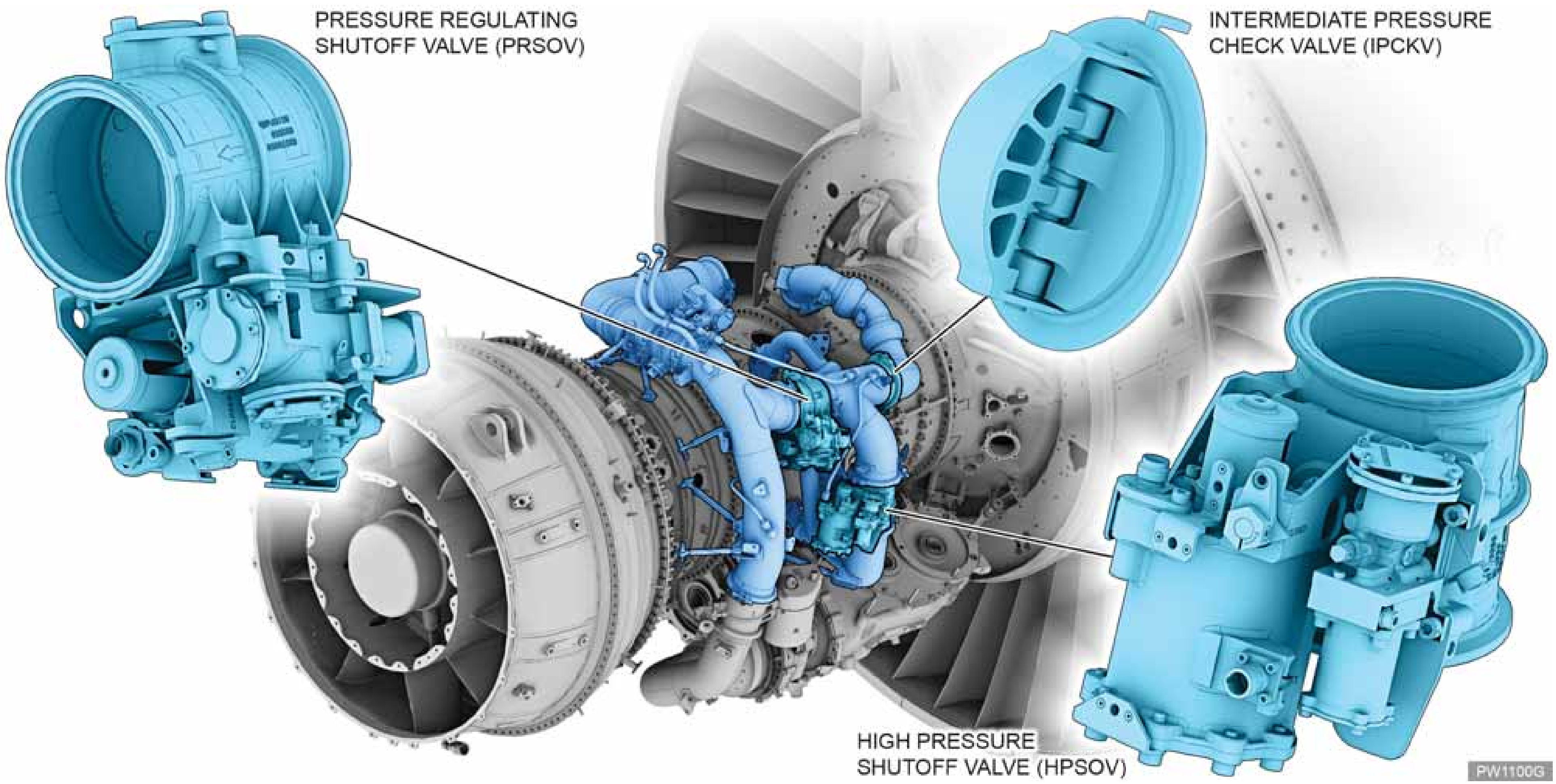
Bleed air coming from the HPSOV or IPCKV is cooled via the pre-cooler, prior to being sent into the aircraft Pneumatic System.

The Pneumatic System uses hot air from both the HPC's high pressure, 8^{th} Stage port and intermediate pressure, 3^{rd} Stage port. It automatically switches between the two depending on pressure.

During normal operating conditions, the High Pressure Shutoff Valve (HPSOV) is closed, allowing the Intermediate Pressure Check Valve (IPCKV) to open and HPC 3^{rd} Stage air to supply the Pneumatic System.

The Pressure Regulating Shutoff Valve (PRSOV) regulates the bleed air pressure that supplies the pneumatic systems on the aircraft. An Overpressure Valve (OPV) in the pylon protects the pneumatic system ducts if abnormally high pressure is delivered from the engine.

Bleed air is cooled by the Pre-Cooler Exhaust (PCE) using cold fan air flow that is modulated by the Fan Air Valve (FAV). In case of engine failure or bleed system overpressure/failure, the valves can be closed to isolate the system.



PNEUMATIC SYSTEM

PNEUMATIC SYSTEM (Cont.)

High Pressure Shutoff Valve (HPSOV)

Purpose:

LRU PMT

The High Pressure Shutoff Valve controls the source of air for the Pneumatic System.

Location:

The HPSOV is located on the right side of the engine at 3:00, just aft of the IFPC.

Description:

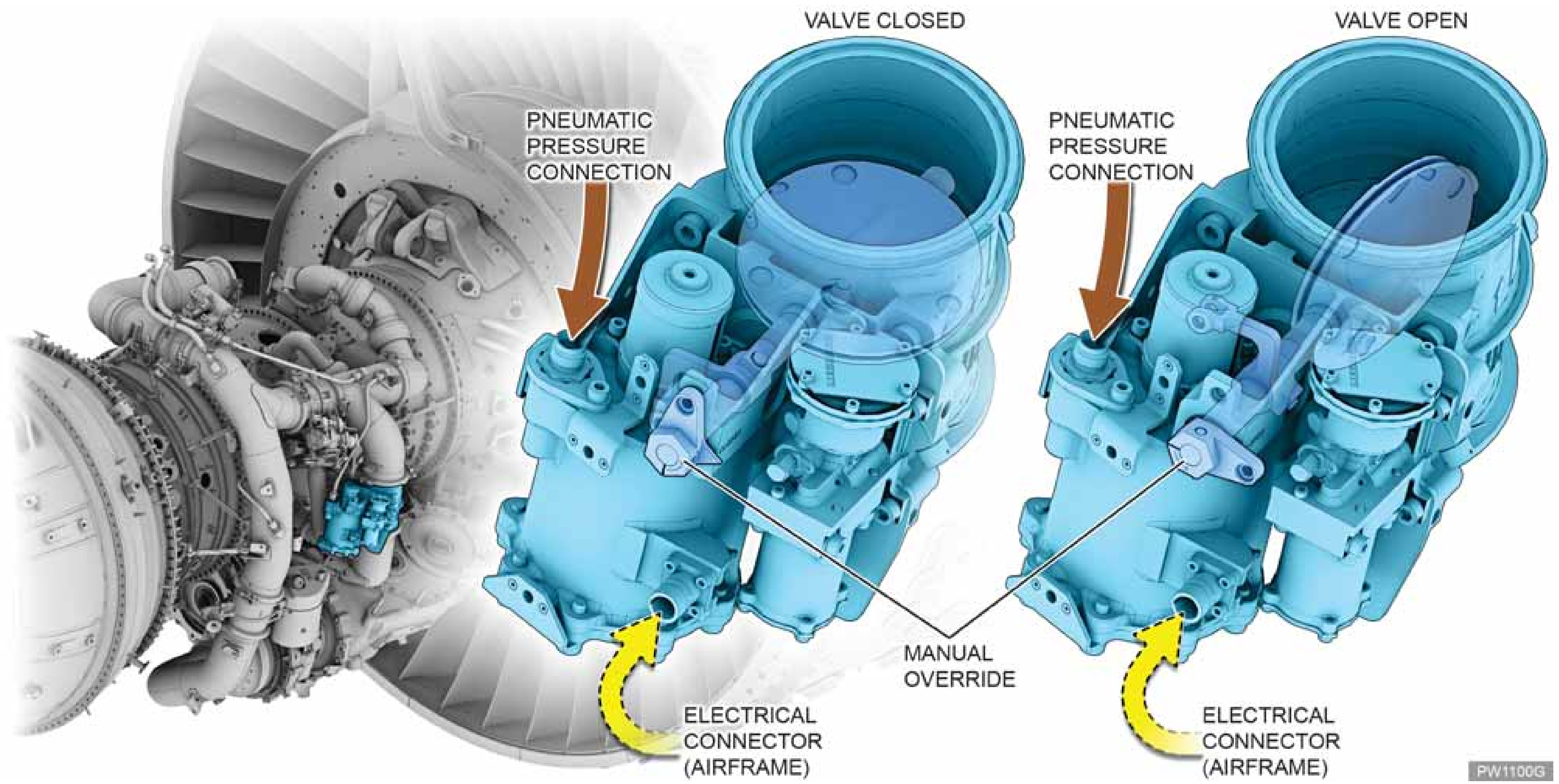
The HPSOV contains a butterfly valve assembly, a pneumatic actuator, and a solenoid. The valve is pneumatically controlled using muscle air from both upstream and downstream of the valve. The solenoid is controlled by the aircraft's two Bleed Management Computers.

The HPSOV features a manual override to lock the valve position in the event of failure occur.

Operation:

When, the HPSOV is energized, upstream air pressure is released into the valve body, opening the butterfly valve and allowing HPC 8^{th} stage air into the pneumatic system. When the solenoid is de-energized, downstream air pressure entering the valve body moves the butterfly valve into a closed position.

The bleed management computers command the HPSOV to open when low air pressure is sensed within the pneumatic system, such as during low power operation.



PNEUMATIC SYSTEM – HIGH PRESSURE SHUTOFF VALVE

PNEUMATIC SYSTEM (Cont.)

Pressure Regulating and Shutoff Valve (PRSOV)

Purpose:

LRU PMT

The Pressure Regulating and Shutoff Valve regulates air pressure from the HPC.

Location:

The PRSOV is located on the right side of the engine just below the ACC inlet duct at 2:00.

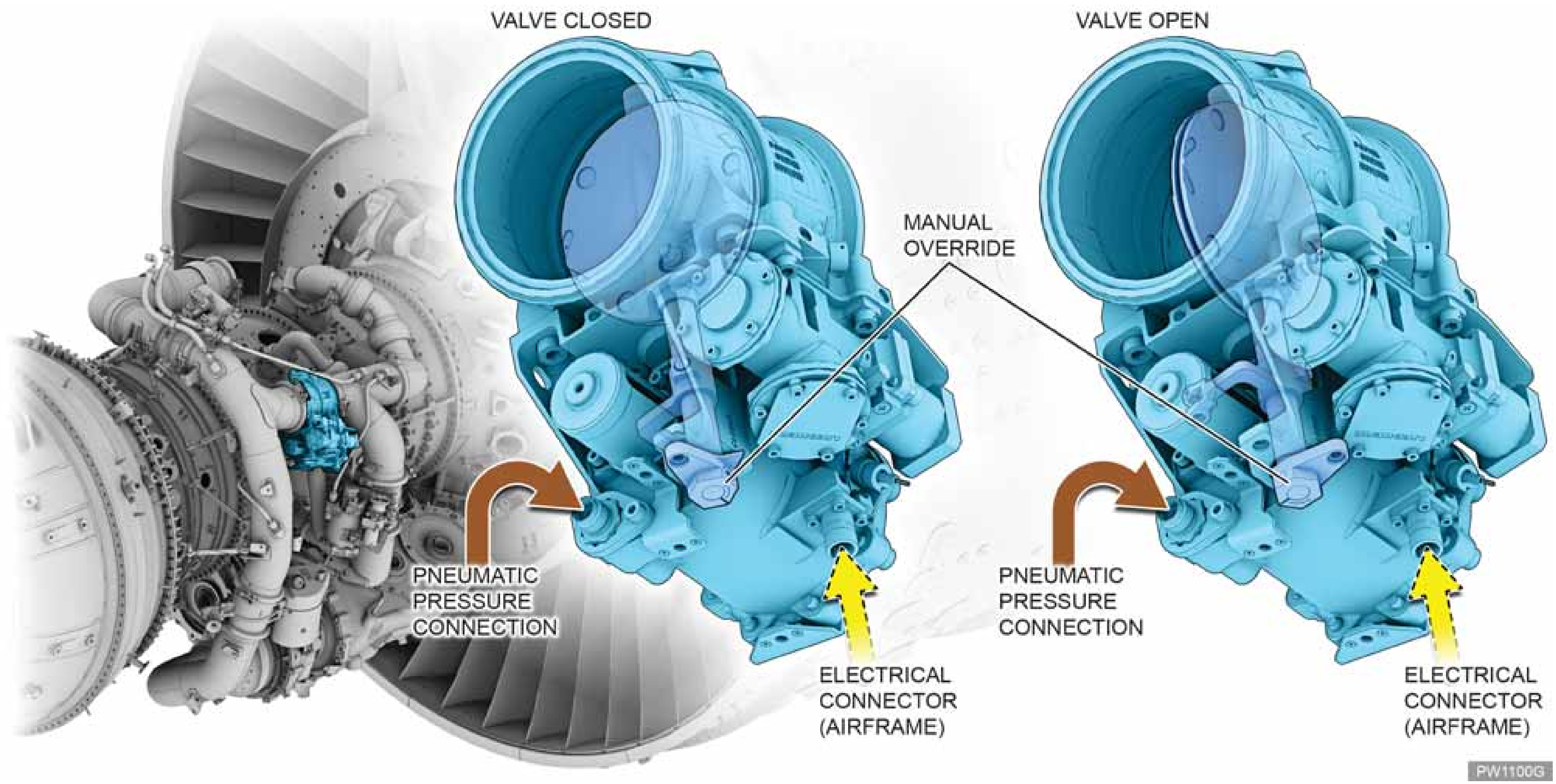
Description:

The PRSOV is pneumatically operated by a solenoid which is controlled by the aircraft Bleed Management Computers. Muscle air from both upstream and downstream of the valve are used to operate the butterfly valve assembly. A thermal fuse installed in the valve body causes the valve to close when the air temperature rises above a prescribed limit.

Operation:

The PRSOV regulates the incoming pneumatic system pressure to a prescribed maximum. To protect the aircraft, the PRSOV is automatically closed during the following conditions:

- overtemperature or overpressure detected downstream of the valve
- ambient overheat detected nearby in the pylon, wing, or fuselage
- APU bleed valve not closed
- engine fire pushbutton switch is activated.



PNEUMATIC SYSTEM – PRESSURE REGULATING AND SHUTOFF VALVE

PNEUMATIC SYSTEM (Cont.)

Intermediate Pressure Check Valve (IPCKV)

Purpose:

LRU PMT

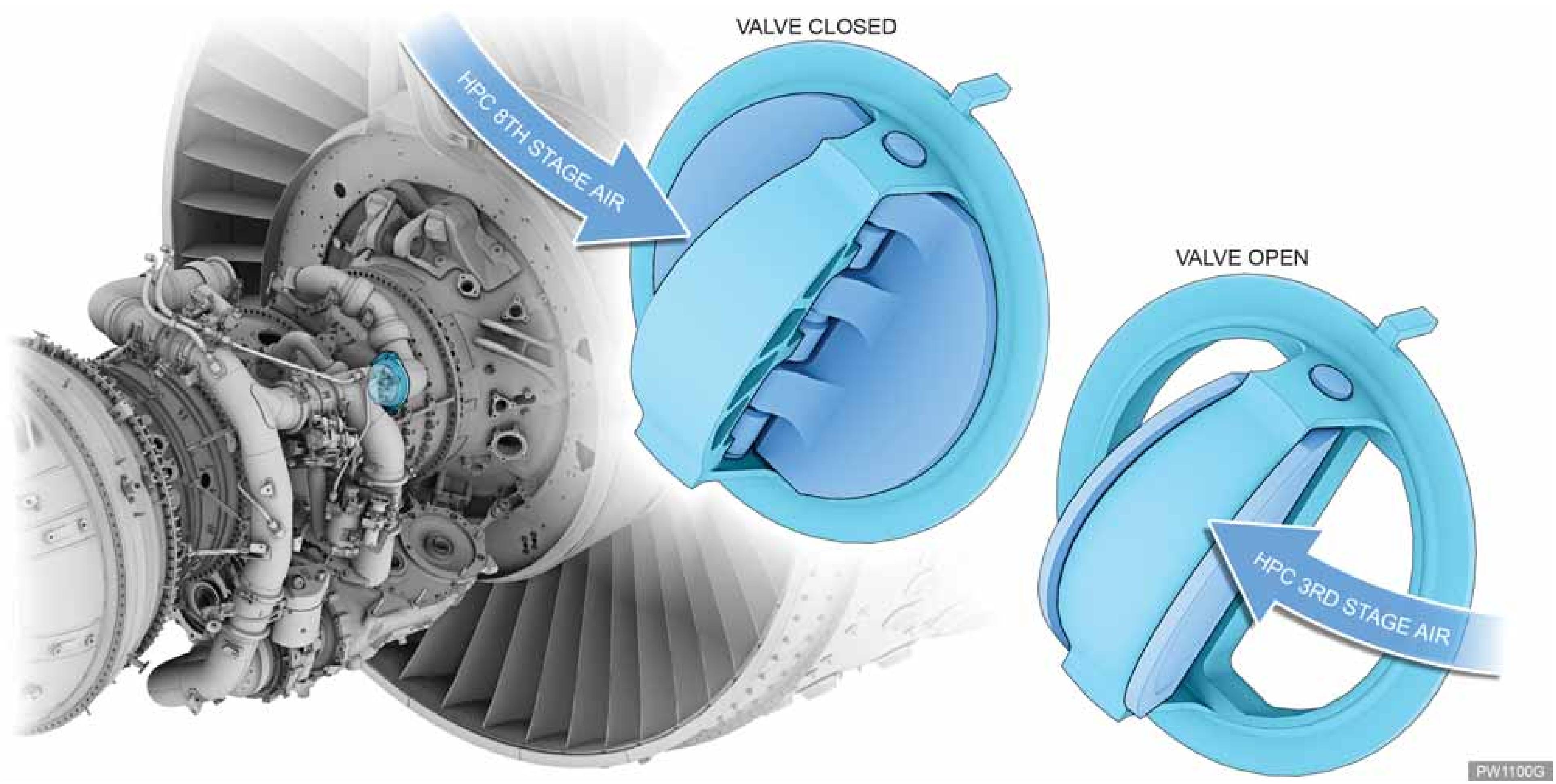
The Intermediate Pressure Check Valve allows the flow of HPC 3rd Stage air to the Pneumatic duct when the High Pressure Shutoff Valve is closed.

Location:

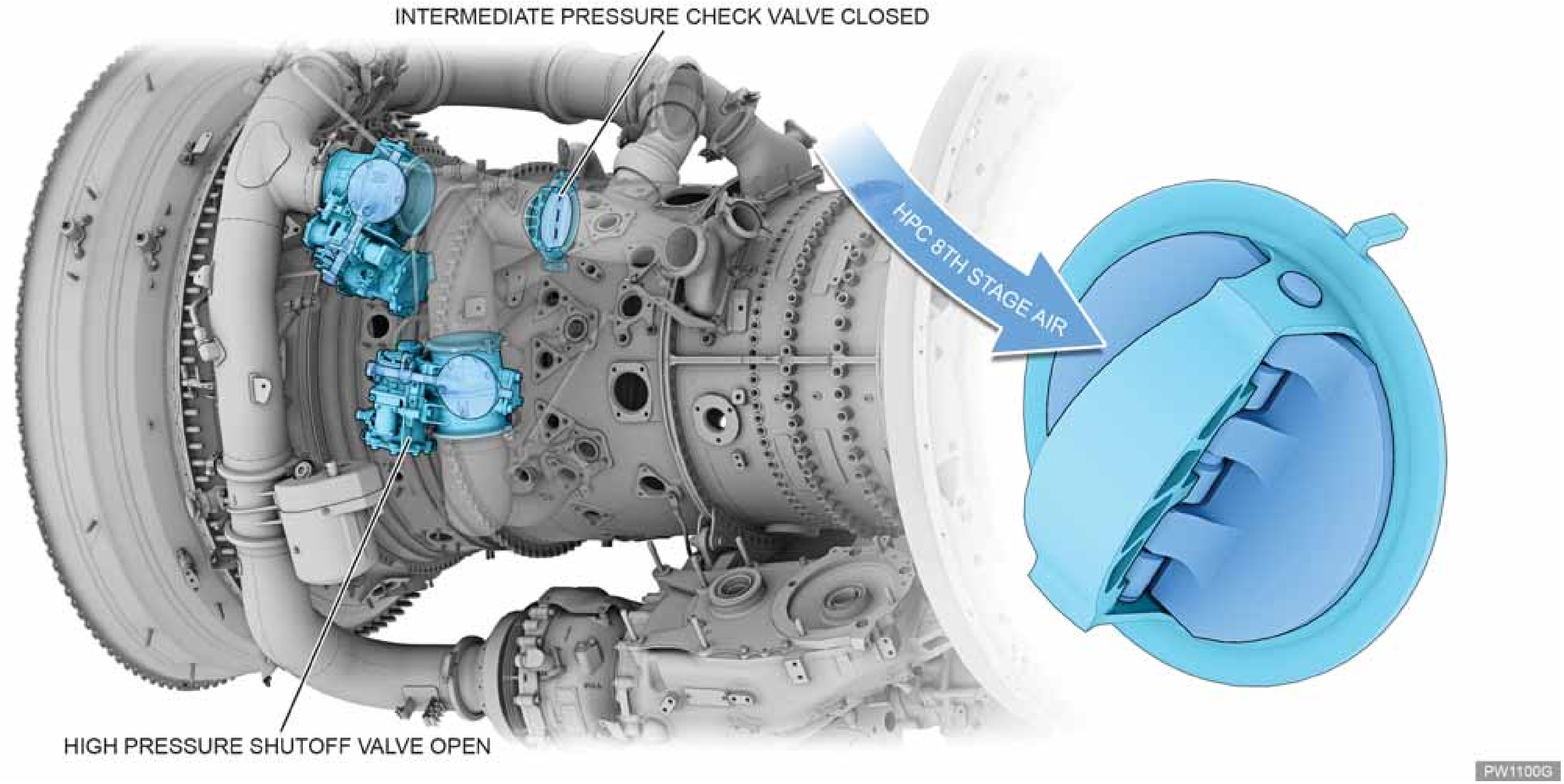
The IPCKV is located inside the mid-stage Pneumatic duct at 2:00.

Description:

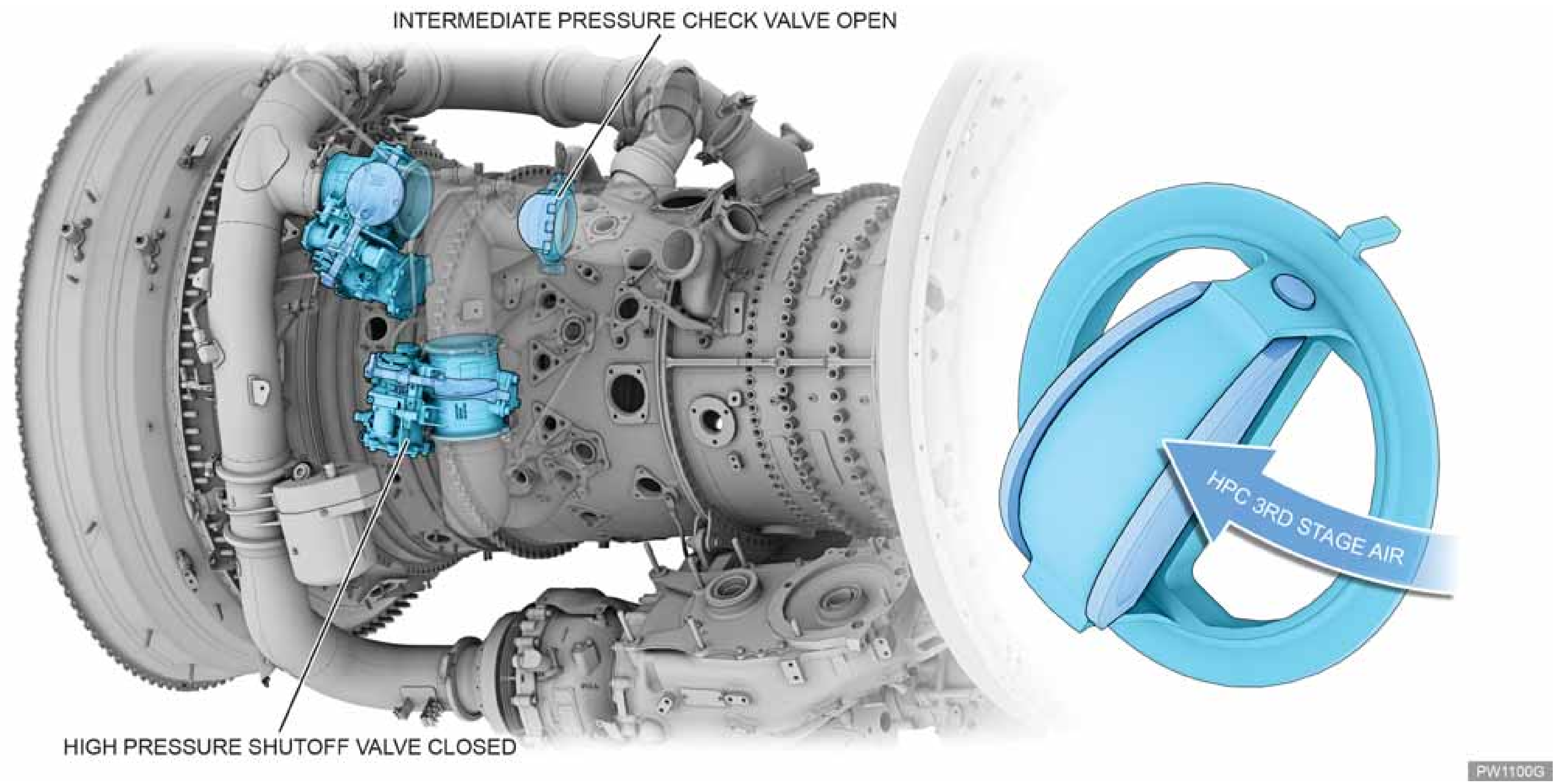
The IPCKV is a split flapper valve.



PNEUMATIC SYSTEM – INTERMEDIATE PRESSURE CHECK VALVE



PNEUMATIC SYSTEM – AIRFLOW AT LOW POWER



PNEUMATIC SYSTEM – AIRFLOW AT HIGH POWER

CHAPTER 11

STANDARD PRACTICES

ATA 70

OBJECTIVES

1. State the effects of improper torqueing.
2. Identify the locking devices used on a PW1100G turbine engine.
3. Describe the correct methods for installing a preformed packing.
4. List five issues to check when installing loop clamps.
5. Describe the purposes of anti-gallant and anti-seize lubricants.

OVERVIEW

Standard practices describe tools and methods for safely performing engine maintenance tasks. Tools and methods include:

- torqueing
- locking devices
- preformed packings
- clamps
- lubricants.

TORQUEING

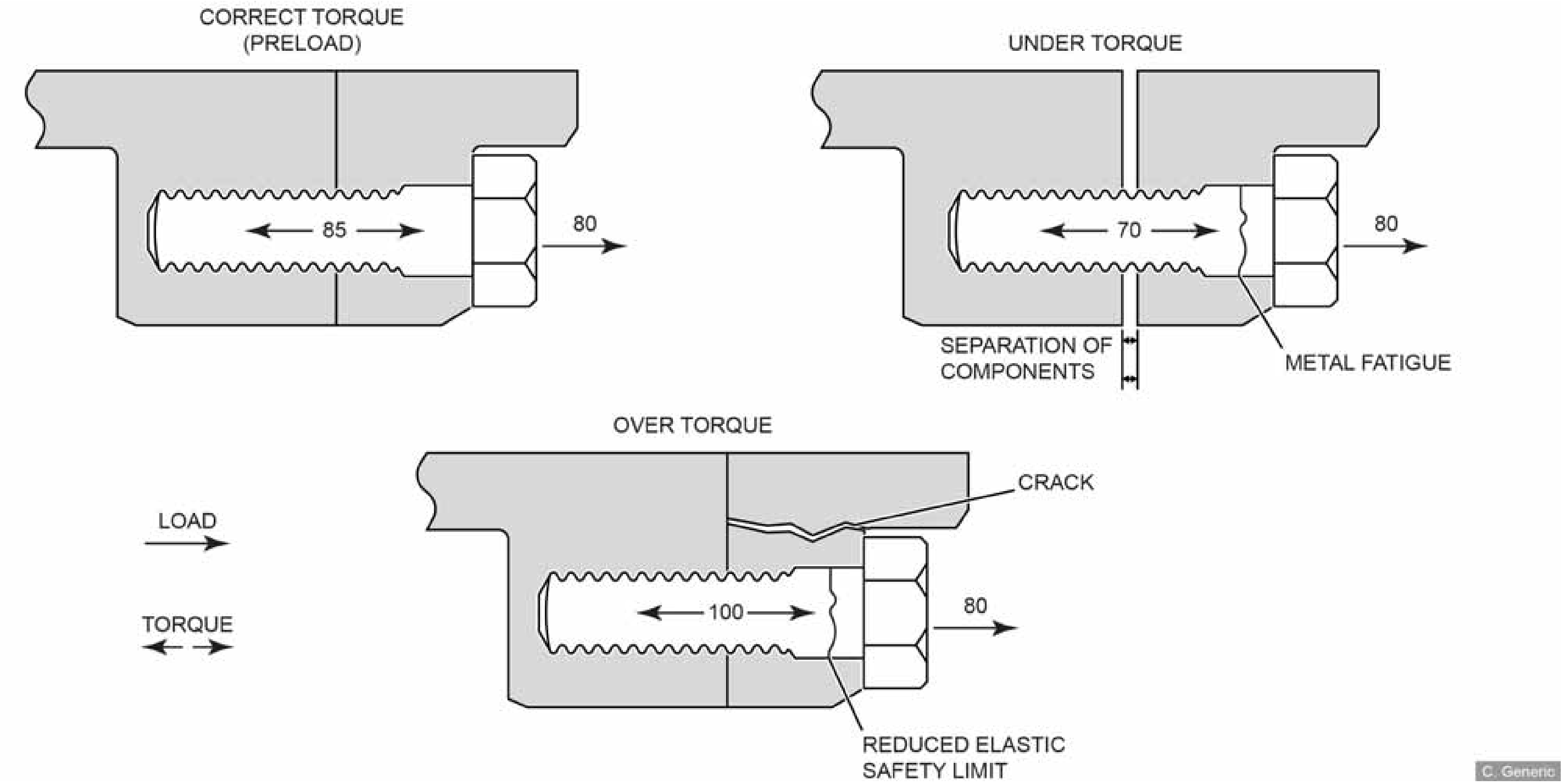
Torque is the turning force that produces rotation or torsion. Standard torqueing practices describe how to safely tighten hardware. Refer to the Standard Practice Operating Procedure.

The term for the amount of tension that is naturally present when assembling hardware is called *preload*.

Torque should always be greater than the load or stress the part will receive during service.

Torque that is below the minimum required, or *under torque*, will cause a fastener to become stress-relaxed. The fastener can become loose, or fail due to fatigue. For example, it may produce a fractured bolt.

Torque that is above the maximum limit allowed, or *over torque*, reduces the fastener's elastic safety limit and its resistance to shear stress. Additionally, the part being held by the fastener can be damaged. For example, a flange may crack.



PRINCIPLES OF TORQUE

TORQUEING (Cont.)

Indicating Devices

Sixty to ninety percent of torque is used to overcome the friction of the thread, the seating surface of the nut, or both.

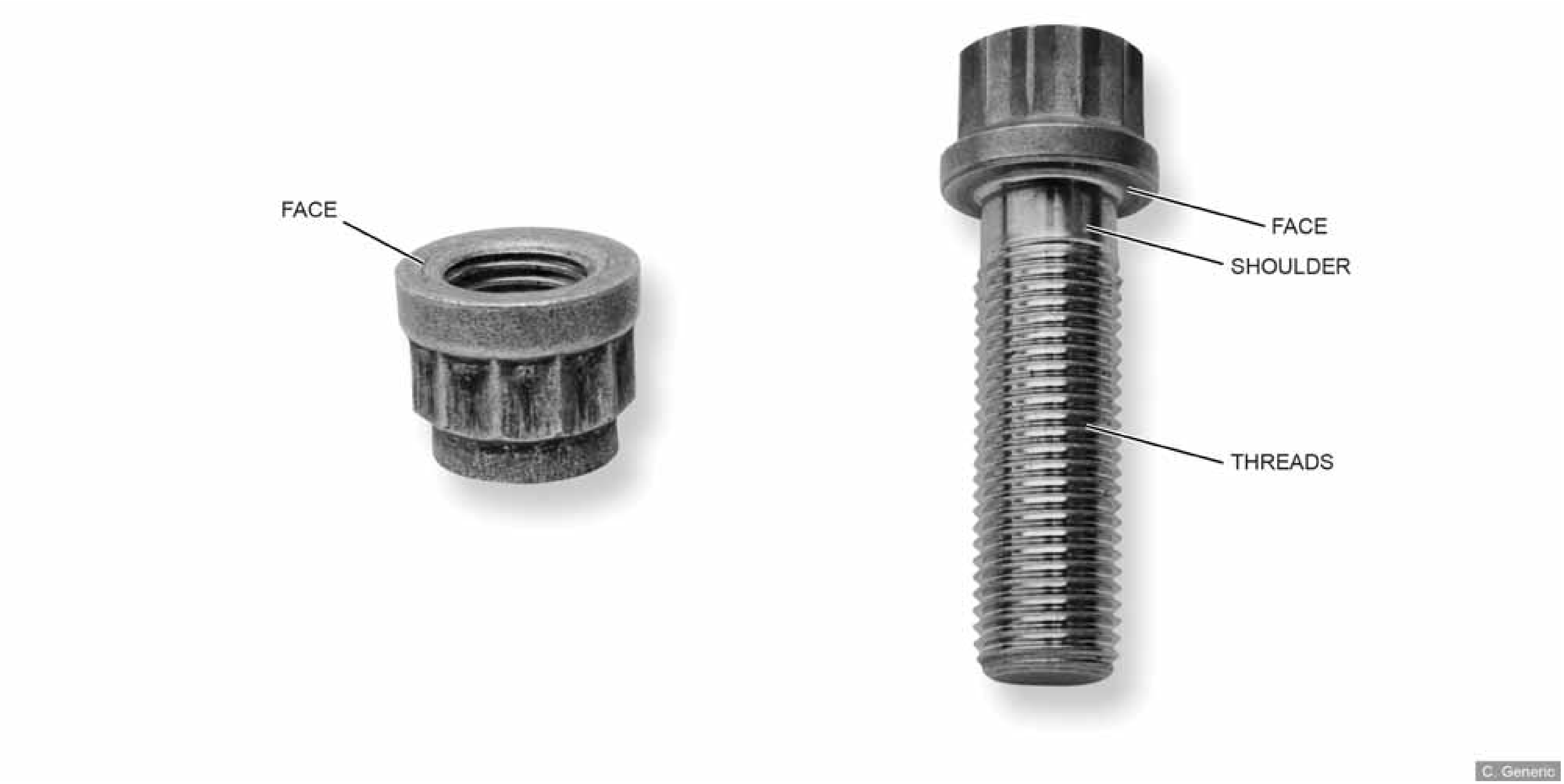
Lubricants reduce and stabilize friction on the threads and other load-bearing surfaces. Without proper lubrication, bolted connections may not receive the correct torque at assembly, which could result in separation of parts during engine operation.

Solid film lubricants coat the surface of the threads that physically separate the surfaces. The coating drastically reduces the metal-to-metal contact between the high points. Use the lubricant compounds recommended in the assembly instructions. Apply thin coatings and follow cure procedures.

Proper lubrication helps achieve correct preload of bolted connections.

Final torque values depend on whether a lubricant is used. Lubricant should be applied to fasteners whenever they are torqued, unless otherwise specified in the maintenance manual.

Torque limits apply specifically to the use of engine oil or its equivalent on the parts and to the use of anti-gallant compounds. Torques on non-lubricated threads, including silver-plated threads, are classified as special torques.



LUBRICATED PARTS

TORQUEING

Indicating Devices (Cont.)

Check torque indicating devices and calibrate regularly. Do not calibrate by comparing one torque wrench with another. For reliable and accurate results, torque wrenches should be used according to manufacturer's instructions.

Torque wrenches are precision instruments. Never use a torque wrench for anything other than its intended purpose.

Do not use torque wrenches to loosen fasteners. Never torque fasteners to a setting that exceeds capacity or the adjusted setting at -10 percent.

Choose the correct size torque wrench for the task being performed. Return the torque setting to zero when finished.

Store torque wrenches in a container built for the purpose.

C. Generic

TORQUE WRENCH EXAMPLES

LOCKING DEVICES

Locking devices prevent loosening of torqued fasteners due to stress, vibration and temperature change.

Locking devices include:

- cotter pins
- cup washers
- key washers
- lockwire
- safety cable.

Locking devices are used on torqued fasteners such as bolts, screws, nuts, plugs, caps and connectors.

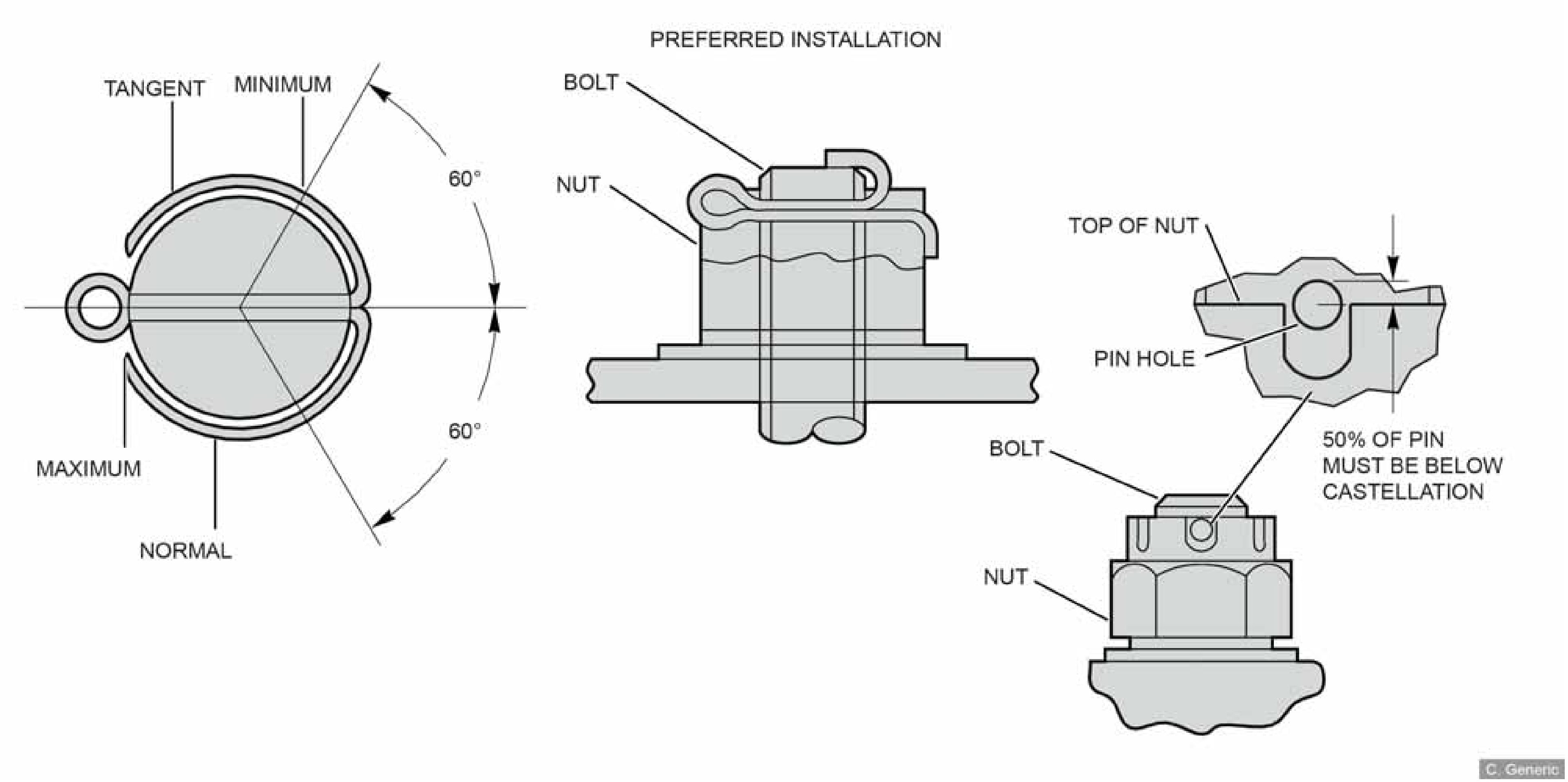
TYPES OF LOCKING DEVICES

LOCKING DEVICES (Cont.)

Cotter Pins

Use new cotter pins for each installation. Check the technical manual to specify the correct cotter pin for the application.

1. Tighten nut to low side of prescribed torque range.
2. Make sure the slot aligns with the hole in the bolt shank.
   - If the slot and bolt shank do not align before maximum torque is exceeded, loosen the nut and repeat the procedure.
   - If the slot still does not line up before maximum torque is exceeded, use a new nut and/or bolt and repeat the procedure outlined above.
   - If half or more of the cotter pin diameter is above the nut castellation, obtain a new nut and repeat the procedure.
3. Install pin with the head seated snug to the fastener. Be sure not to force the pin through the fastener. This would deform the head. The axis of the eye must be at a right angle to the bolt shank.
4. Bend cotter pin prongs so that the head and upper prong are firmly seated flat against the nut wrench.
   - If necessary, cut prongs to provide clearance or tight fit against bolt shank or nut wrench flat.
   - When installing cotter pin, the eye should be parallel to the shank of the pin or rod end.
   - If necessary, cut prongs to get the normal end position as shown on the next page.


PREFERRED INSTALLATION
TANGENT
MINIMUM
60°
60°
MAXIMUM
NORMAL
BOLT
NUT
TOP OF NUT
PIN HOLE
BOLT
NUT
50% OF PIN
MUST BE BELOW
CASTELLATION
C. Generic

COTTER PIN

LOCKING DEVICES (Cont.)

Cup Washers

- Cup washers can be used only once.
- Cup washers must be positioned so the tab of the washer is in the loosening direction of the fastener being secured.
- A cup washer should not move during assembly.
- After forming the indentations, the washer should not be broken, cracked or torn.
- The cup washer should not shake or rattle after installation.

Use the correct tooling when crimping cup and key washers.

The tool part that forms indentations must be spherical with a radius of not less than 0.050 inch.

Safety Conditions

CAUTION

DO NOT FORM INDENTATIONS ON THE FUEL NOZZLE CUP KEY WASHERS BY IMPACT.

NOTE: TOOLING RECOMMENDATIONS ARE LOCATED IN THE STANDARD PRACTICES MANUAL OR TECHNICAL MANUAL.

TOOLING CAN BE MADE BY PRATT & WHITNEY AND/OR LOCALLY MANUFACTURED (WORKING END DIMENSIONS ARE IN THE DIAGRAMS CONTAINED IN THE TECHNICAL MANUALS).

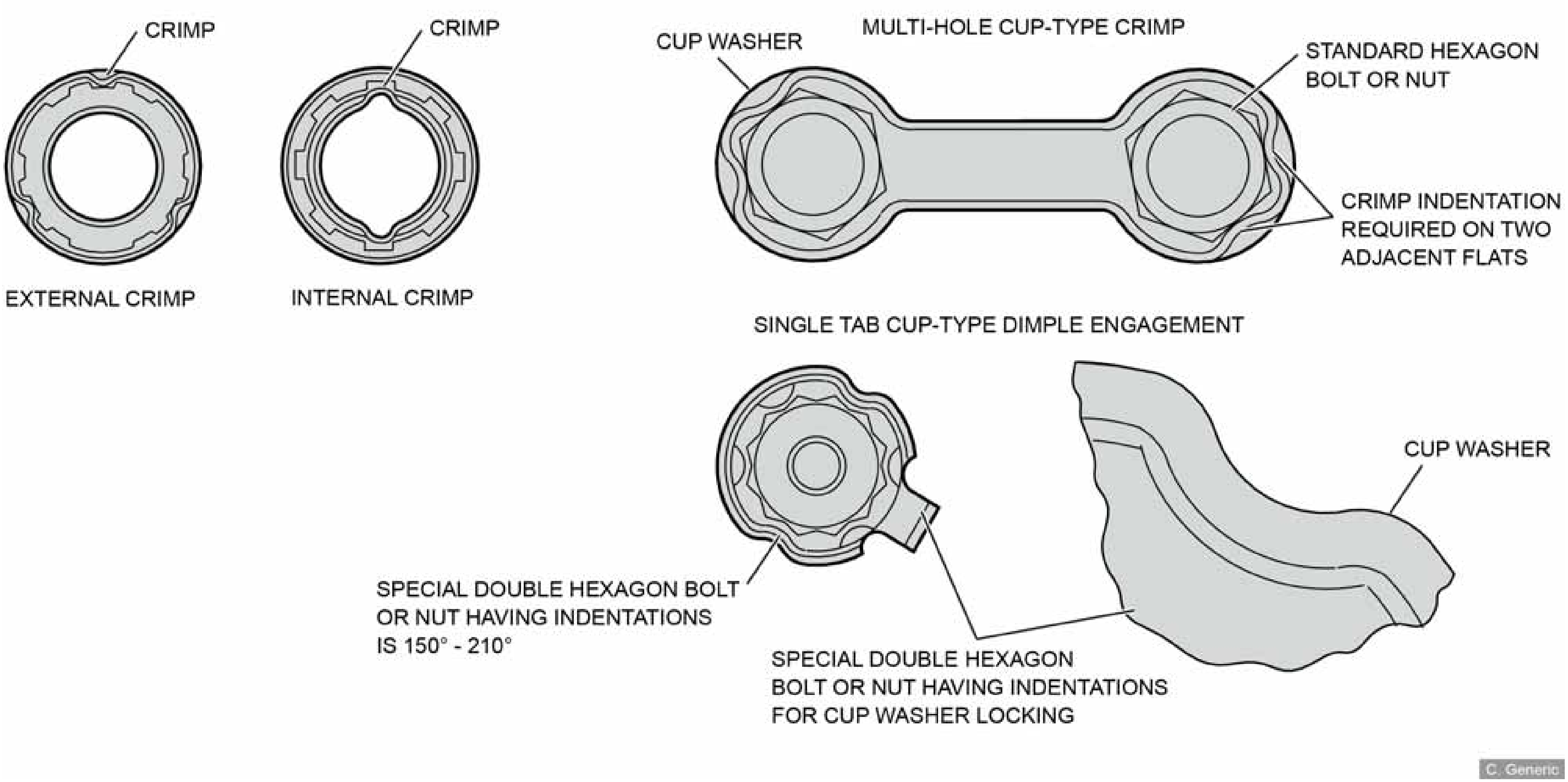
Squeeze Action Crimping Tool

Press the outer diameter of the cup key washer into the slots of the nut or bolt to make indentations. This tool is recommended and must be used where possible.

Drift Tool

The drift tool makes indentations when placed on the outer diameter of the cup key washer and moved in an axial direction.

This tool is also called a *punch* because a hammer is used to drive indentations into the washer. It has a ring with prongs on the inner diameter.



CUP WASHER CRIMPING

LOCKING DEVICES (Cont.)

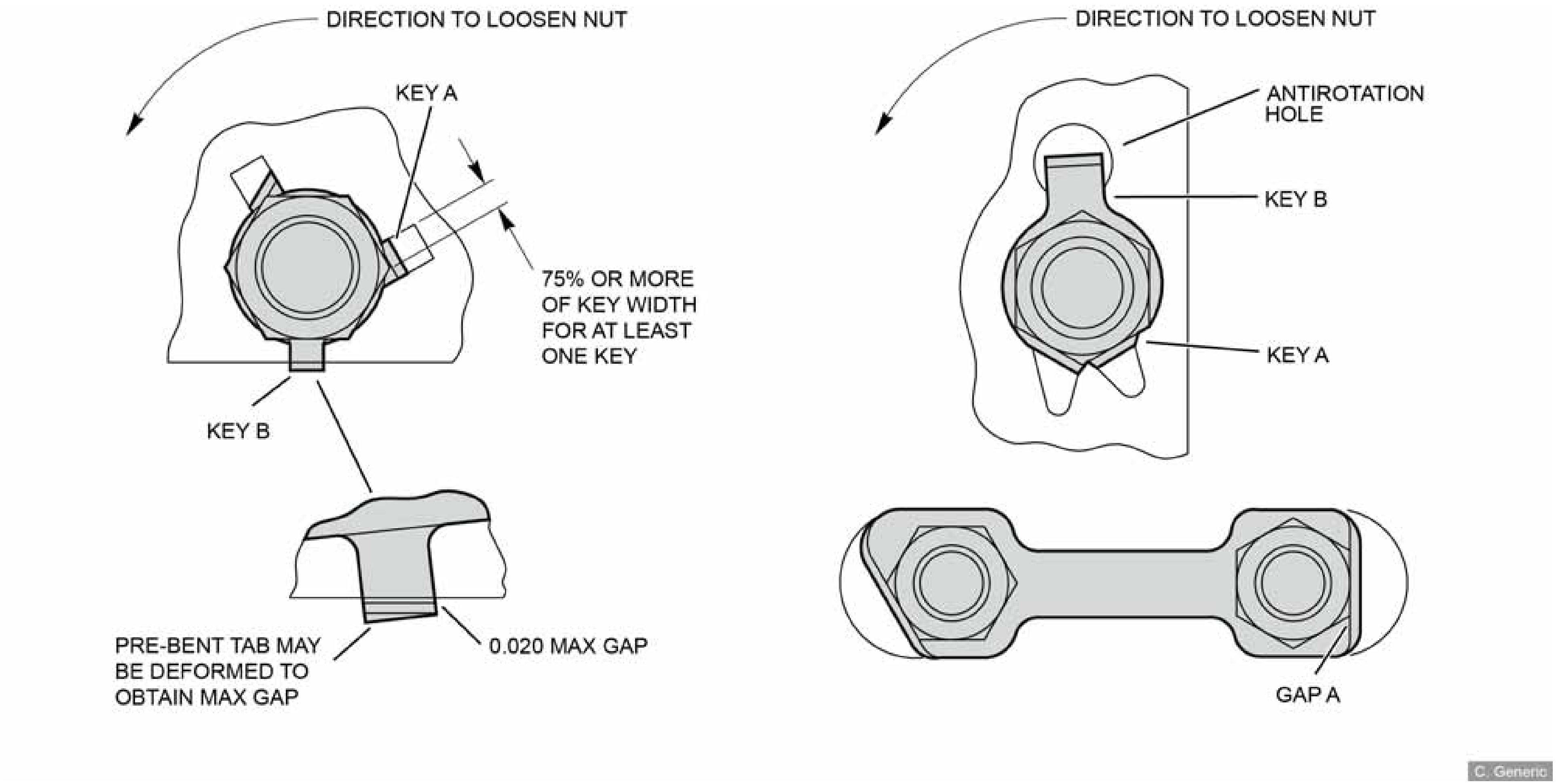
Key Washers

Use key washers only once. Key washers must measure 75 percent or more of width as measured at the base of the key. They must touch or be gapped appropriately in relation to the fastener.

1. The pre-bent tab must be tight to the surface or braced against the side of the hole to prevent the fasteners from moving, shaking or rattling.

2. Position the key washer so that unbent keys are away from the axis of the part being locked.

3. Bend all keys.



KEY WASHER INSTALLATION

LOCKING DEVICES (Cont.)

Lockwire

Lockwire consists of two strands double-twisted together, unless otherwise specified.

Single-strand wiring is used for the following conditions only:

- space is so restricted that double-twisted wire will not fit
- double-twisted wire can weaken small or delicate parts.

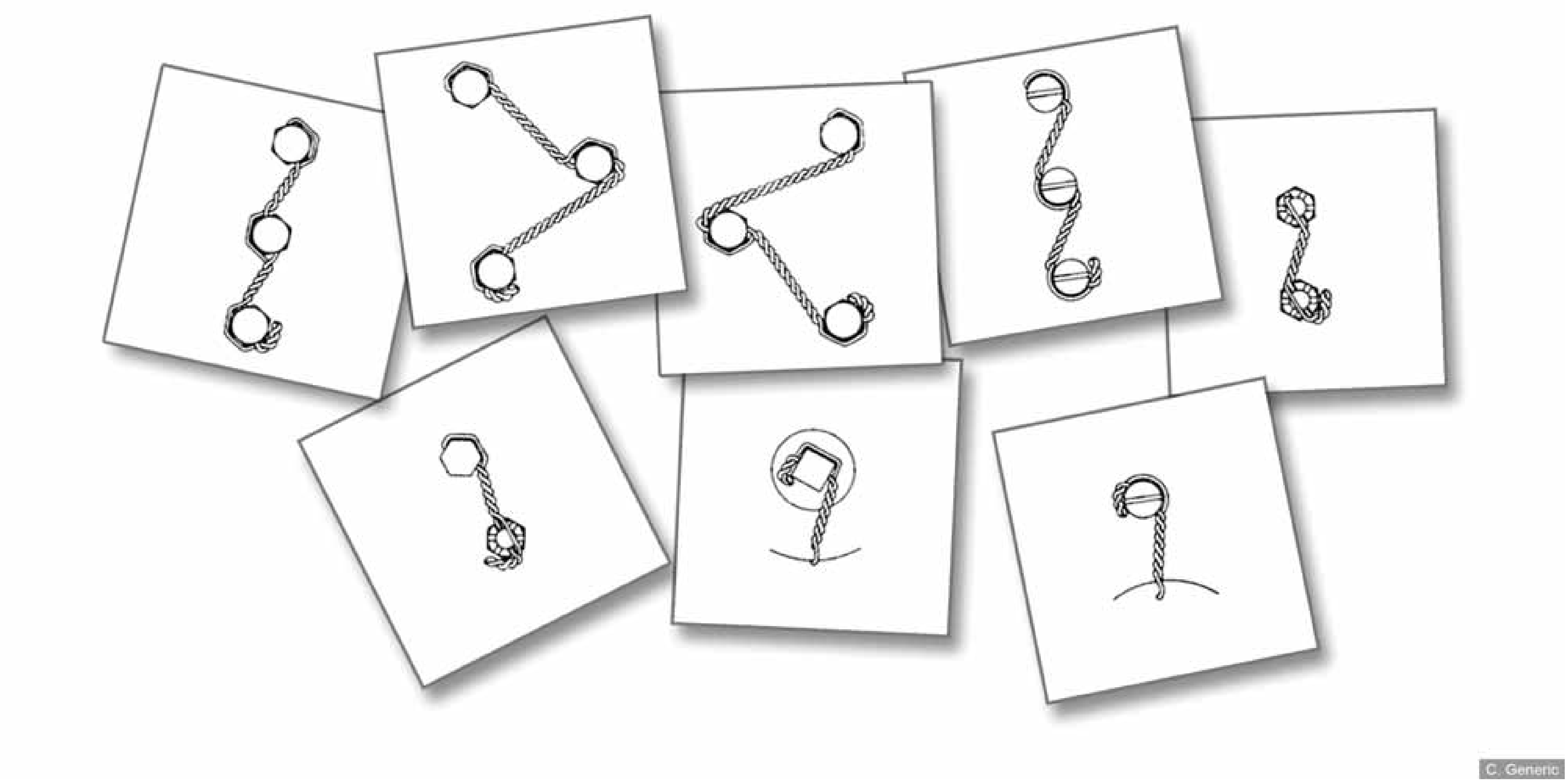
To double twist, pull wire taut and twist. Do not overstress the wire during the twisting operation.

A single twist is done by twisting the wires through an arc of 180˚, the equivalent to one-half of a complete turn.

NOTE

The correct size wire for the job is located in the Engine Manual assembly instructions.

- Ensure that maximum span of safety wire is 6 inches (152.4 mm).
- Do not lockwire more than four units in a series with a continuous length of wire.
- Install safety wire carefully. It must not be nicked, kinked, or damaged during installation.
- Do not expose safety wire to wear, chafing, or excessive load after installation.



LOCKWIRE CONFIGURATIONS

LOCKING DEVICES

Lockwire (Cont.)

Lockwiring Steps

1. Tighten and torque hardware correctly before locking with safety wire.

2. Do not increase or decrease the torque on parts to align the wire holes. Use another bolt to align the wire holes within the specified torque limits.

3. Pull safety wire tight as you twist it. The twisted portion of the wire must be within 1/8 inch from the hole in any unit.

4. Pull the wire in a way that puts no torque on the threaded part. Pull in a direction that will tighten rather than loosen the threaded part.

5. If torque on the threaded part decreases, remove safety wire and re-torque unit to specified values.

6. Cut off excess wire after the last piece of hardware in a series, leaving at least three twists.

7. Bend the remaining wire into the part to avoid sharp or jutting ends. These could become a safety hazard or vibrate in the air stream and eventually break.

LOCKING DEVICES (Cont.)

Safety Cable

The maximum span between two points is 6 inches (152 mm), unless specified by the engine manual.

Do not use cable if you find any cable defects, such as nicks, frays, kinks or damage.

Do not reuse safety cable or ferrules. A ferrule is a small metal collar that fastens around the cable and locks the cable in place.

Check the safety cable and ferrule before beginning the job for pull-off and flex limits.

NOTE

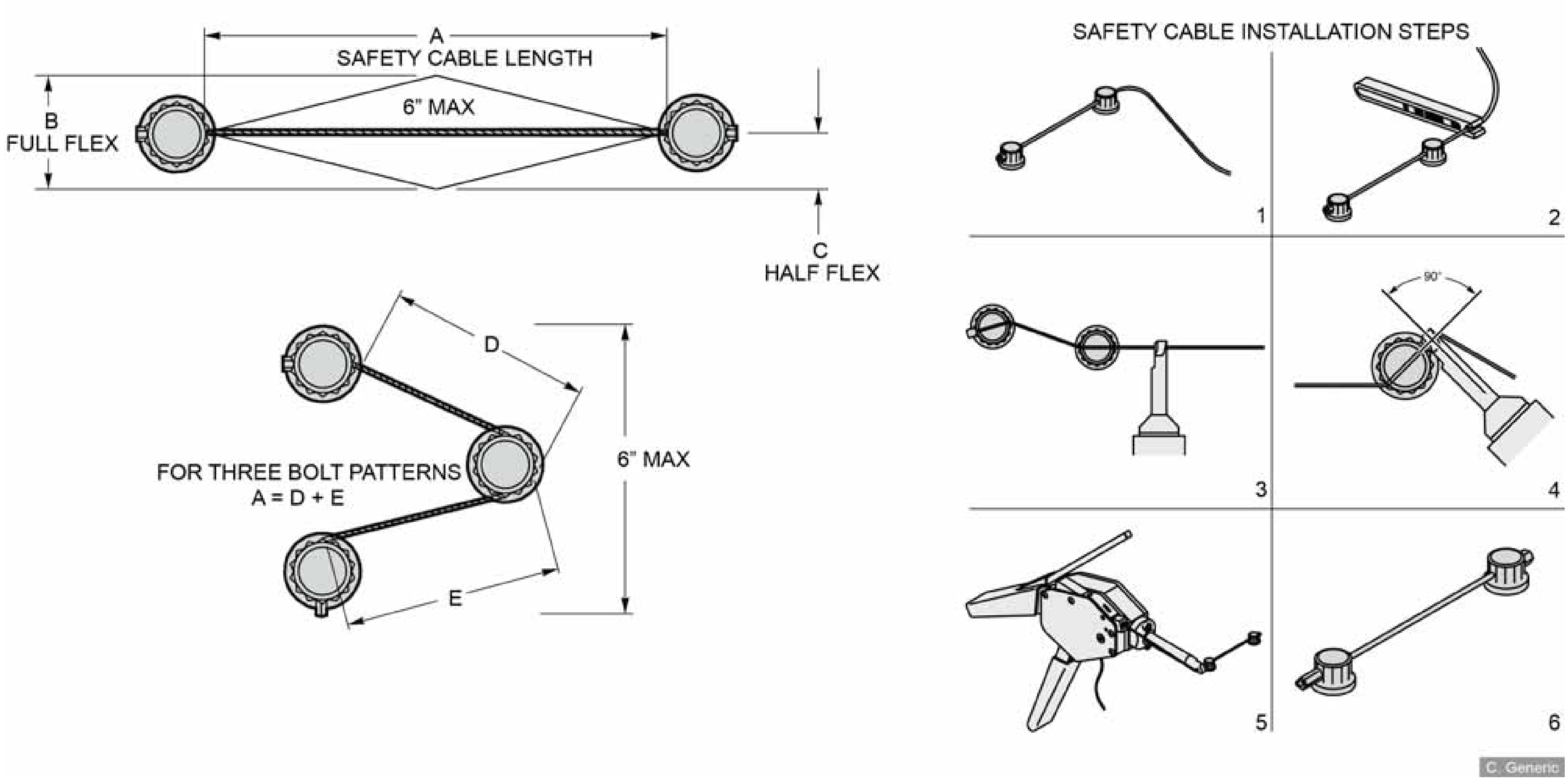
If possible, do not turn more sharply than 135° when cable goes through the fasteners. This technique provides the installation of safety cable with either a positive or neutral pull.

Best Practices

1. Install safety cable in two or three bolt patterns, unless otherwise specified. Two bolt patterns are preferred when working with an even number of fasteners.
2. Ensure the tip of the tools are square to the ferrule, which should be square to the hardware being secured.
3. Check the calibration of the ferrule crimping tool before use.
4. Do not increase or decrease the torque on engine hardware to align holes for application of safety cable.
5. Install cable in the direction that tightens it.

Safety Cable Installation Steps

1. Install the cable through the object fasteners.
2. Install the ferrule onto the cable.
3. Insert the cable through the tip of the cable gun.k
4. Ensure the tool is set at a 90° angle to the fastener.
5. Squeeze the handle.
6. Check the cable for the proper tension.



SAFETY CABLE PROCEDURES

PREFORMED PACKINGS

Preformed packings, called *O-rings,* provide a tight, leak-free seal between two adjoining parts.

Packings are made of three types of material.

- Fluorocarbon packings are primarily used in oil systems. They should be lubricated with assembly fluid, oil or petrolatum before installation.
- Fluorosilicone packings are used only in fuel systems and are specified for external sealing of fuel components because of their seal capabilities over the temperature range of -65°F to 300°F. They should be lubricated with petrolatum before installation.
- Silicone packings are used only in air and water systems. They should be lubricated with petrolatum only before installation.

Safety Conditions

CAUTION

PETROLATUM IS NOT RECOMMENDED IN FUEL OR OIL SYSTEMS. STUDIES HAVE SHOWN THAT PETROLATUM DOES NOT READILY DISSOLVE IN FUEL OR OIL. EXCESSIVE AMOUNTS CAN CAUSE BLOCKAGE IN SMALL PASSAGES THAT COULD CAUSE ENGINE MALFUNCTION OR PLUGGING OF FILTERS.

System	Packing
Oil or fuel	Fluorocarbon
Fuel	Fluorosilicone
Air, water, and alcohol	Silicone

TYPES OF PREFORMED PACKINGS

PREFORMED PACKINGS (Cont.)

Recommended installation practices are listed below.

- Pre-lube packings before installation.
- Use plastic caps to protect O-rings from installation damage over threads.
- Push an O-ring into position as opposed to rolling it.
- Use the specified O-ring part number as per applicable manual.
- Avoid the use of sharp tools when installing.
- Avoid damaging O-rings with your fingernails.

Safety Conditions

CAUTION

REPLACE ALL PACKINGS AT EVERY OVERHAUL.

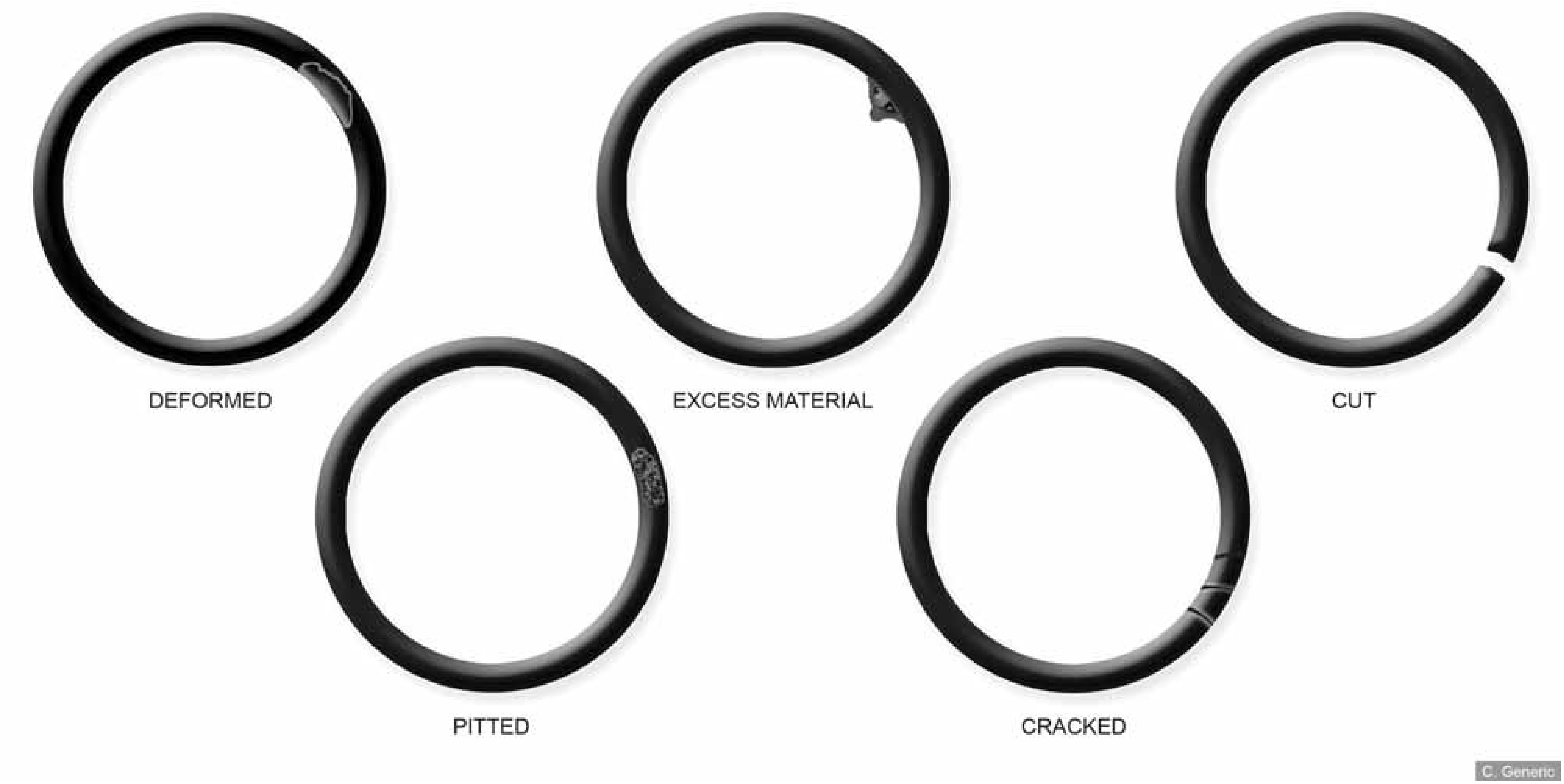
DO NOT RETIGHTEN PACKING GLAND NUTS; RETIGHTENING WILL, IN MOST CASES, INCREASE RATHER THAN DECREASE A LEAK.

DO NOT DEPEND ON COLOR-CODING. CODING MAY VARY WITH MANUFACTURER.

RETAIN REPLACEMENT SEALS IN THEIR PACKAGES UNTIL READY FOR USE. THIS PROVIDES PROPER IDENTIFICATION AND PROTECTS THE SEAL FROM DAMAGE AND CONTAMINATION.

ENSURE THE SEALING SURFACES ARE CLEAN AND FREE OF NICKS OR SCRATCHES BEFORE INSTALLING THE SEALS.

BE SURE THE SEAL HAS NOT TWISTED DURING INSTALLATION.



TYPICAL O-RING DEFECTS

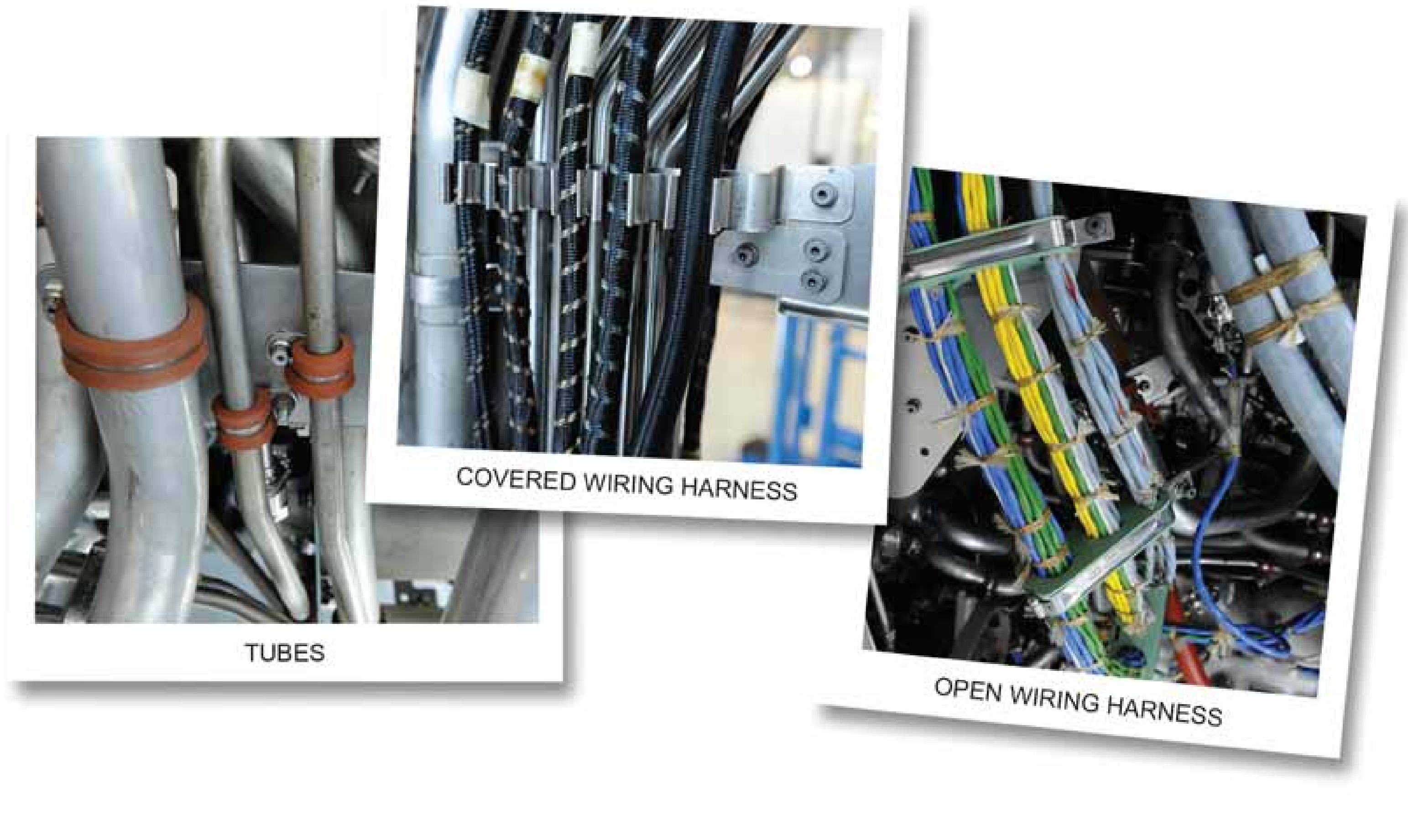
CLAMPS

Clamps perform these functions:

- holding the various sensing, electrical and feedback harnesses in place
- securing fuel, air and oil lines
- protecting the various harnesses and lines against vibration.

Wire Harness Clamp Selection

Clamp sizes allow for variations in wire harness diameter. Use only the appropriate clamp for the task and engine model you are working on.



CLAMPS

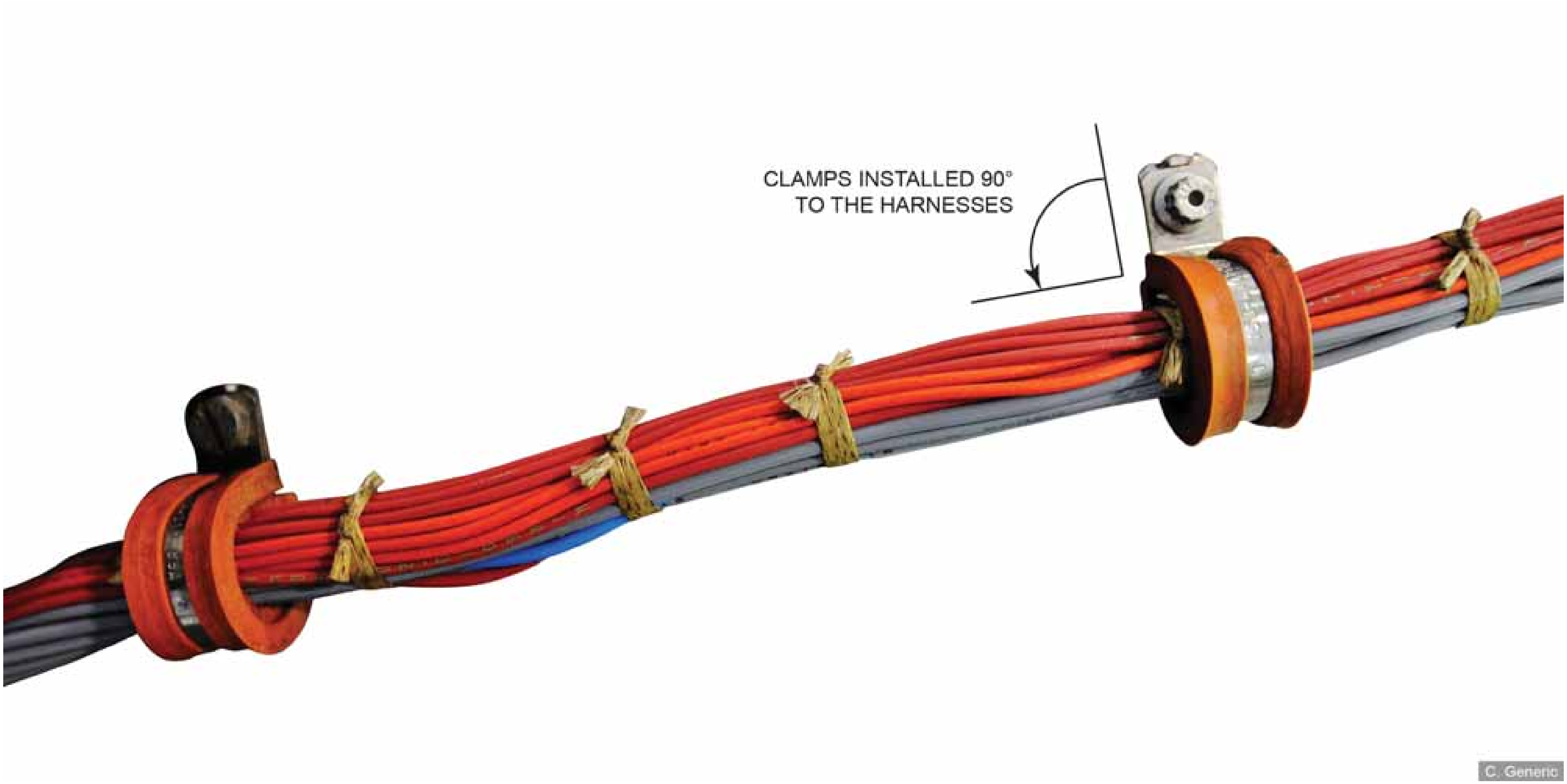
CLAMPS (Cont.)

Harness Clamp Installation

Clamps must be installed 90° to the harnesses or tubes.

To install:

1. Route harness loosely according to appropriate technical data.
2. Install clamps loosely, making certain all wires are within the cushion position of the clamp.
3. Secure electrical connectors to the harness clamp.
4. Tighten all clamp bolts and nuts to recommended standard torque values.



HARNESS CLAMP INSTALLATION

CLAMPS (Cont.)

Inspecting and Replacing Clamps

The replacement of worn or broken clamps is crucial in preventing chafed tubes and the loss of oil or fuel.

Check loop clamps for clamp drooping or distress and mesh compacting or deterioration. Replace any broken loop clamps and any worn or missing mesh.

Check rubber silicone clamps for cracking or chunking rubber and deterioration, exemplified by reddish powder around the clamp.

If clamps are removed, check the tube for chafing at clamp locations.

If clamps are installed, check that the clamp is installed squarely on the tube.

If the clamp is cocked, remove the clamp and check for wear.

Safety Conditions

CAUTION

REPLACE WORN OR BROKEN CLAMPS WITH NEW CLAMPS TO PREVENT CHAFED TUBES AND THE LOSS OF OIL OR FUEL.

TYPICAL CLAMP DAMAGE AND WEAR

CLAMPS (Cont.)

Wire Harness Spring Clips

Wire harness spring clips allow for easier harness installation and removal compared to clamps. Harnesses are pressed into spring clips for installation and pulled out of spring clips for removal.

Closed-bundle wire harnesses are manufactured with extra length to allow for repair. New harnesses will have extra slack when installed on an engine. This slack must be managed to avoid contact between the harness and other items, such as engine cases, flanges, components, other harnesses, or the nacelle.

NOTE

Harness contact may result in wear of the harness overbraid, called "chafe." Harness chafe can be repaired with chafe tape.

GP7200

HARNESS SPRING CLIP INSTALLATION

TYPICAL WIRE HARNESS SPRING CLIP DAMAGE AND WEAR

LUBRICANTS

Anti-gallant and anti-seize are solid film lubricants that are applied between two mating surfaces to protect from damage during movement by reducing friction and wear.

Anti-gallant prevents galling in blade root and disk slots. Galling occurs when material is removed from a surface by welding together, then shearing the small area of two surfaces that slide across each other under pressure.

Anti-seize prevents seizing on threaded parts (bolts, nuts, tie-rods, turbine shaft, etc.). Seizing occurs when a moving part is stopped by a mating surface and seizes as a result of excessive friction caused by galling.

Apply anti-seizing compounds at assembly to make it easier to disassemble certain hot section parts, where assembly or maintenance instructions permit.

Use the recommended penetrating oil to facilitate disassembly.

Effective lubricants have the following properties:

- Compatibility to supporting material
- Fluid resistance (oil, fuel, water, etc.)
- low co-efficient of friction
- load carrying capacity
- thermal stability
- torque-tension capability.

Apply extreme pressure lubricants to prevent galling of highly stressed areas (spline drives, case snaps, bearing journals), when assembly instructions recommend. The pre-load is the most important factor for an effective connection on the bolt. This is accomplished by torqueing, but 60-90% of torque is lost in the friction of the thread and under the bolt head or the nut seating surface.

Lubrication reduces and stabilizes friction of the fasteners. It will allow disassembly later without seizing or thread damage.

Safety Conditions

CAUTION

EXTREME CARE MUST BE USED TO ENSURE THAT ANTI-GALL AND ANTI-SEIZE COMPOUNDS ARE APPLIED IN A THIN, EVEN COAT AND THAT ALL EXCESS MATERIAL IS COMPLETELY REMOVED TO AVOID CONTACTING OTHER PARTS, PASSAGES, OR SURFACES CAUSING MALFUNCTIONING OR ENGINE FAILURE.

THREAD AREAS PRONE TO SEIZING

CHAPTER 12

TROUBLESHOOTING

ATA 31

OBJECTIVES

1. Recognize the definition of troubleshooting.
2. Identify and interpret types of fault messages.
3. Recognize fault codes and their application.
4. Complete troubleshooting steps using data sources below.

• Electronic Centralized Aircraft Monitor	ECAM
• Post Flight Report	PFR
• Multipurpose Control and Display Unit	MCDU
• Centralized Fault Display System	CFDS
• airnav^{X}	
• Troubleshooting Manual	TSM

OVERVIEW

Troubleshooting, or fault isolation, is the method of identifying and isolating sources of engine problems, or *faults*. Faults are detected by the EEC and are communicated to the aircraft through fault messages that describe the engine problem in general terms. Additional sources must be referenced to identify the specific nature of the fault and proceed to isolate its cause.

Fault messages fall into three types, based on how and when they are communicated, and the length of time allowed for resolution.

- Class 1 faults may have consequences on aircraft safety and availability on the current flight. They are indicated to the crew in flight by the ECAM system and warnings in the cockpit.
- Class 2 faults do not have consequences on aircraft safety and availability for the current or following flights. However, consequences might occur as the result of a second fault. These faults are indicated to the cockpit crew on ground by a Maintenance STATUS on the ECAM after engines shut down.
- Class 3 faults have no consequence on aircraft safety or availability. The operator may have these faults corrected when convenient. Class 3 faults are not indicated to the crew. Note that Scheduled Maintenance Report (SMR) faults are similar to Class 3 faults but must be resolved within a limited period of time.

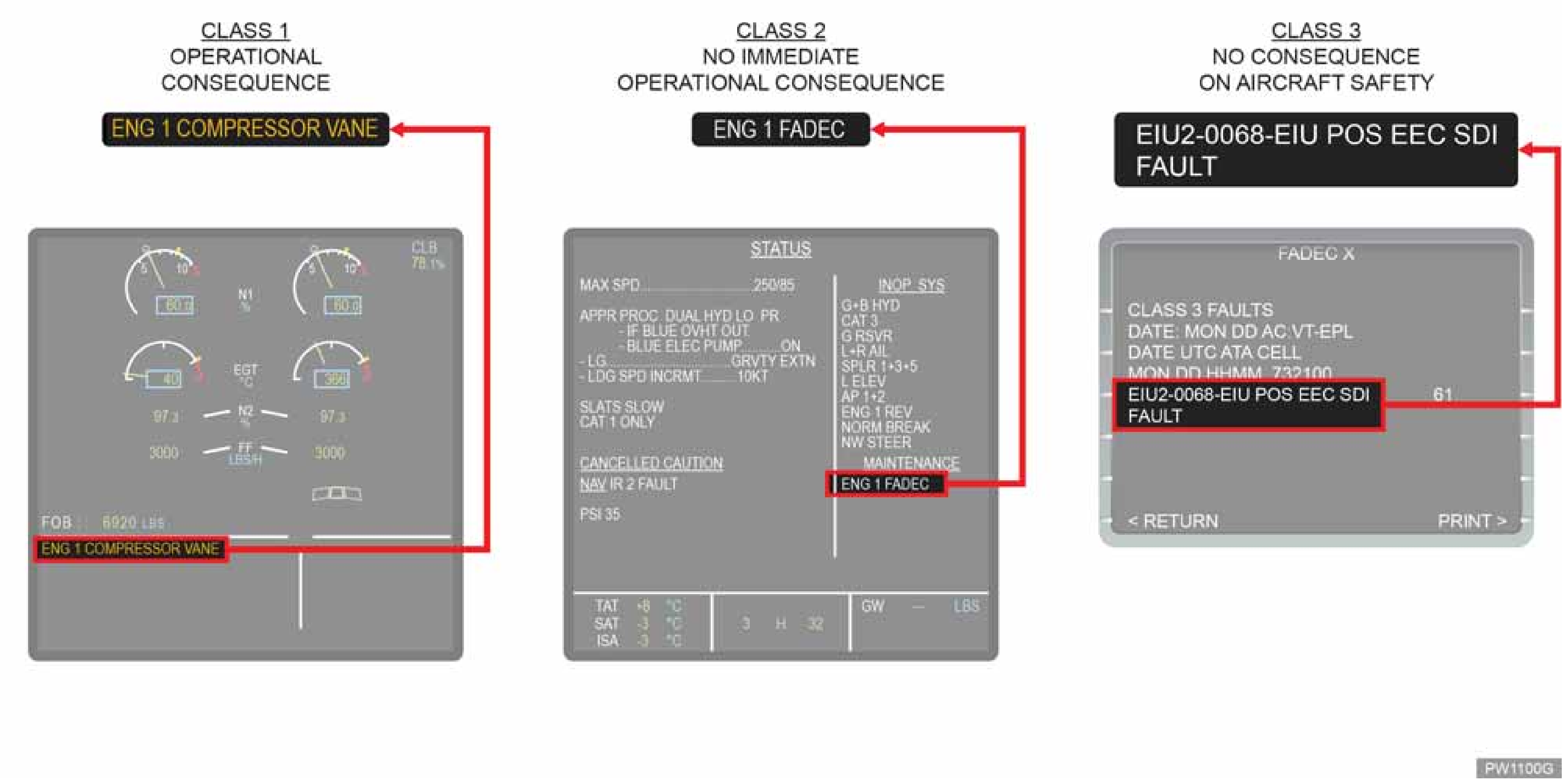
Sources for Identifying Faults

Faults are identified using information gathered from the four data sources below.

- Electronic Centralized Aircraft Monitor (ECAM), the flight deck display system where Class 1 and 2 faults appear
- Post Flight Report (PFR), a printout displaying Class 1 and 2 faults for the most recent flight, plus additional information that identifies the line replaceable component experiencing the fault
- Centralized Fault Display System (CFDS), an aircraft computer that is accessed for data on Class 3 and SMR faults
- Multipurpose Control and Display Unit (MCDU), an aircraft computer that accesses the CFDS to provide fault codes that point to the correct troubleshooting process

Sources for Isolating Faults

Fault isolation requires accessing airnav^{X}, a collection of maintenance manuals. Within airnav^{X} is the Troubleshooting Manual (TSM), a crucial resource that details all probable aircraft faults and offers guidance about fault isolation and resolution.



FAULT MESSAGE TYPES

SOURCES FOR FAULT DATA

Electronic Centralized Aircraft Monitor (ECAM)

ECAM warnings provide only general information that announces the presence of a fault. Class 1 and 2 fault messages are ECAM messages that display in the flight deck.

Class 1 Fault Messages

Class 1 fault messages are split into three levels.

- Level 3 corresponds to warnings needing immediate crew action. These warnings are associated with a repetitive audible chime or specific sound, a red warning message on the upper ECAM, and a flashing red Master Warning light.

  Sample message: **ENG 1 OIL LO PR**

- Level 2 corresponds to abnormal situations needing immediate crew awareness but not necessarily immediate action. These warnings are associated with a single audible chime, an amber warning message on the upper ECAM and a steady amber Master Caution light.

  Sample message: **ENG 1 OIL HI TEMP**

Level 1 corresponds to general cautions on the upper ECAM and is mainly used for failures leading to a loss of redundancy, or to system degradation. These messages are associated with an amber caution light.

Sample message: **ENG 1 OIL FILTER CLOG**

UPPER ECAM CLASS 1 FAULT DISPLAY

SOURCES FOR FAULT DATA

Electronic Centralized Aircraft Monitor (ECAM)

Class 1 Fault Messages (Cont.)

Class 1 messages are advisories that can display “NO GO” or “GO IF” messages relating to departure.

- Fault messages displaying “NO GO” must be fixed prior to the next dispatch.
- Faults displaying “GO IF” may dispatch if certain conditions are met.

See the chart at right for details.

Some class 1 faults have associated fault messages on the Post Flight Report (PFR).

Other indicators that may appear for Class 1 messages include a local warning, a flag, or any invalid function indicator, such as a missing audio signal or amber crosses on a system page.

Note that any fault producing a flight deck effect must be reported by the crew in the aircraft log book.

Message	Meaning
NO GO	Failure must be fixed before the next departure.
GO IF	Departure is allowed only if certain conditions are fulfilled, including all restrictions given in the Minimum Equipment List (MEL).

SOURCES FOR FAULT DATA

Electronic Centralized Aircraft Monitor (ECAM) (Cont.)

Class 2 Fault Messages

Also known as ECAM Maintenance Status messages, or STS, Class 2 messages highlight a problem or degradation in the built-in redundancy of the FADEC system. A Class 2 fault message has no immediate consequence on system operating conditions. The message always indicates GO without restrictions. These faults must be fixed at the first opportunity and not later than the "rectification interval" required as per MEL section.

An ECAM Status Message “STS“ indicator automatically displays on the upper ECAM screen during flight phases 1 and 10. Class 2 messages are also shown on the PFR, but only at the end of the flight, preventing the unwanted distraction of system degradation display.

A Class 2 fault can be left as is for up to 10 days before dispatch (refer to MEL for details). To start proper maintenance action at the first opportunity, information is given to the maintenance teams via a Class 2 maintenance message transmitted to the Centralized Fault Display Interface Unit (CFDIU).

The crew must make an entry into the log book, as this information is provided by the Flight Warning System (FWS) at the end of the flight after engine shutdown via the ECAM STS. The Status Page can then be selected by pressing the STS button on the Systems Page Select Panel. This will provide information under the Maintenance heading on the lower ECAM screen regarding the failure. A screen example is shown below.

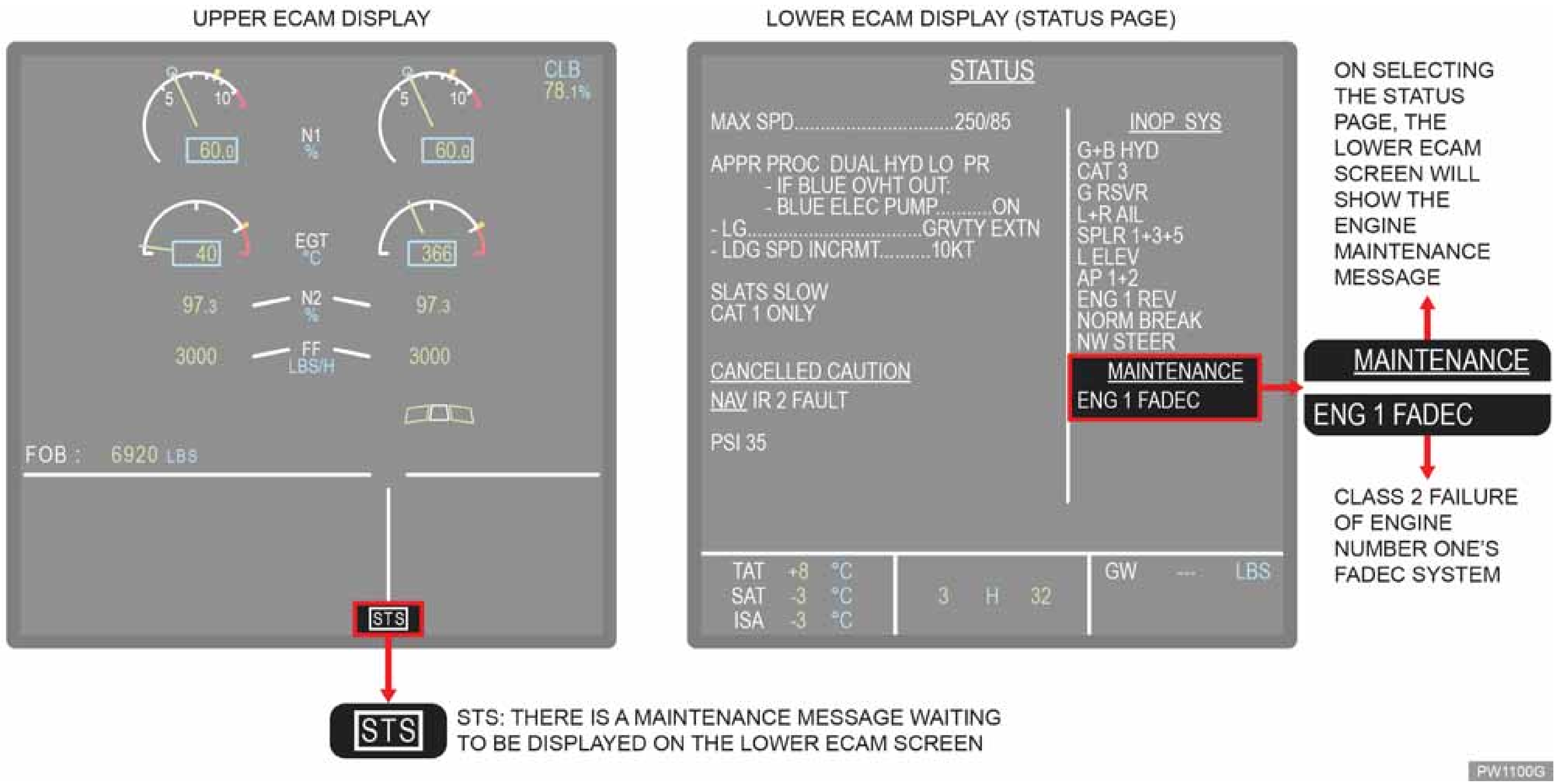
Location	Flight Phase	Occurrence
Lower ECAM screen	1	When electrical power is on, before first engine start
	10	When the second engine has been shut down after flight

MAINTENANCE

ENG 1(2) FADEC

ENG 1(2) EIU

All engine related STS faults are classified under these two categories. Note that the ECAM Maintenance Status should be used to enter the Troubleshooting procedure in airnav^{X} .



ECAM CLASS 2 FAULT DISPLAY

SOURCES FOR FAULT DATA

Electronic Centralized Aircraft Monitor (ECAM) (Cont.)

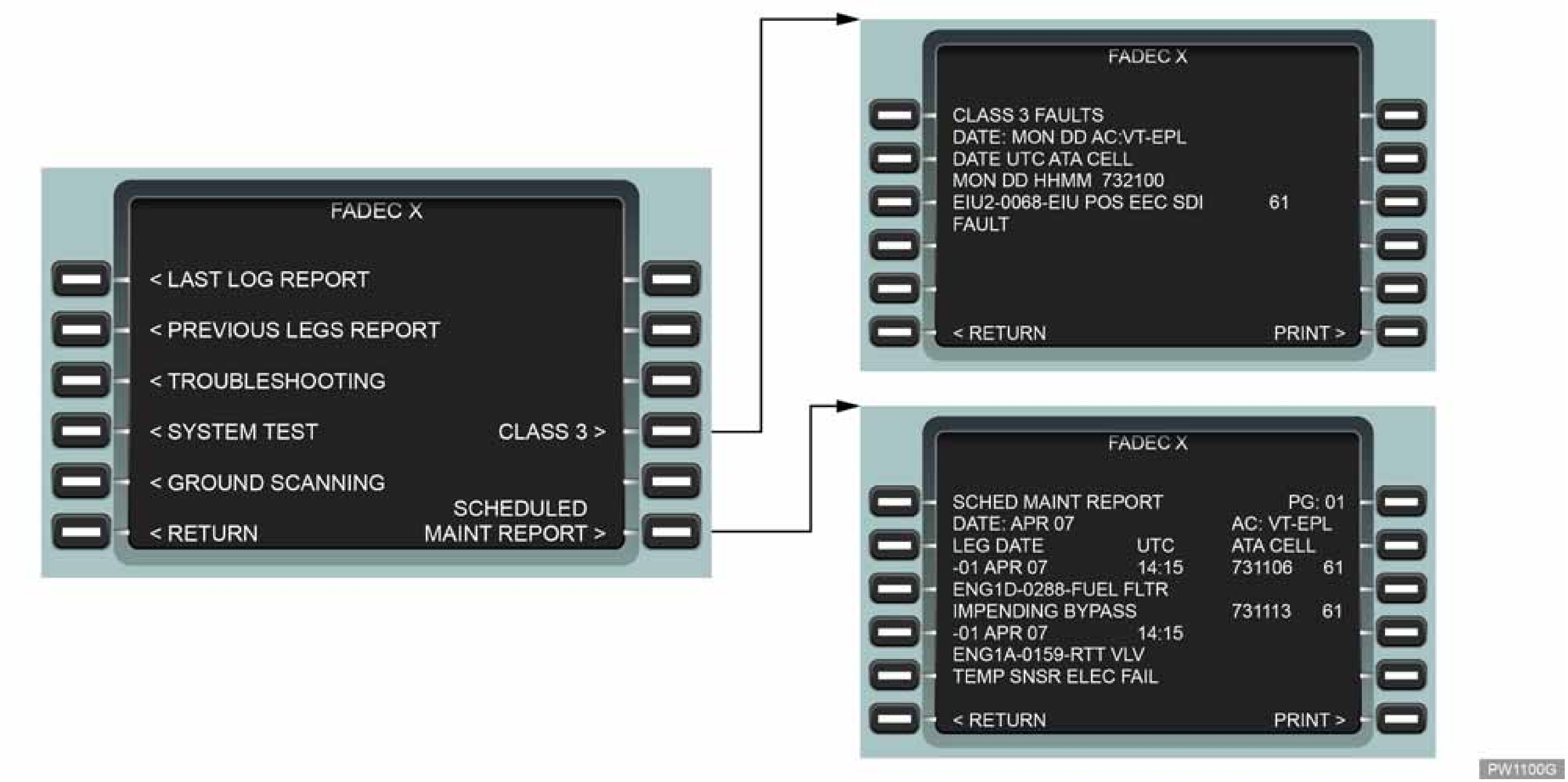
Class 3 Fault Messages

Faults that do not have flight deck events are classified under two categories:

- Scheduled Maintenance Report (SMR) time-limited dispatch faults, which may remain uncorrected within a maximum time frame specified by the Maintenance Planning Document (MPD).
- Class 3 unlimited-time dispatch faults, which may remain uncorrected within an unlimited time frame.

Class 3 and SMR faults are not presented in the Post Flight Report. Both faults have no immediate consequence on system operating conditions. While no time limit is specified for resolution, these faults should be cleared as soon as possible and should not be allowed to accumulate. Clearing these faults reduces risk and workload.

Class 3 and SMR messages can escalate to Class 1 or 2. Maintenance personnel should interrogate the CFDS system frequently.



ECAM CLASS 3 FAULT MESSAGES AND SCHEDULED MAINTENANCE REPORT

SOURCES FOR FAULT DATA

Electronic Centralized Aircraft Monitor (ECAM) (Cont.)

Type	Message Display			Message Availability		Departure Consequences
	ECAM	PFR	CFDIU	Ground	Flight	
1	✓	✓		✓	✓	✓
2	✓	✓		✓		
3			✓			
SMR			✓			

SOURCES FOR FAULT DATA (Cont.)

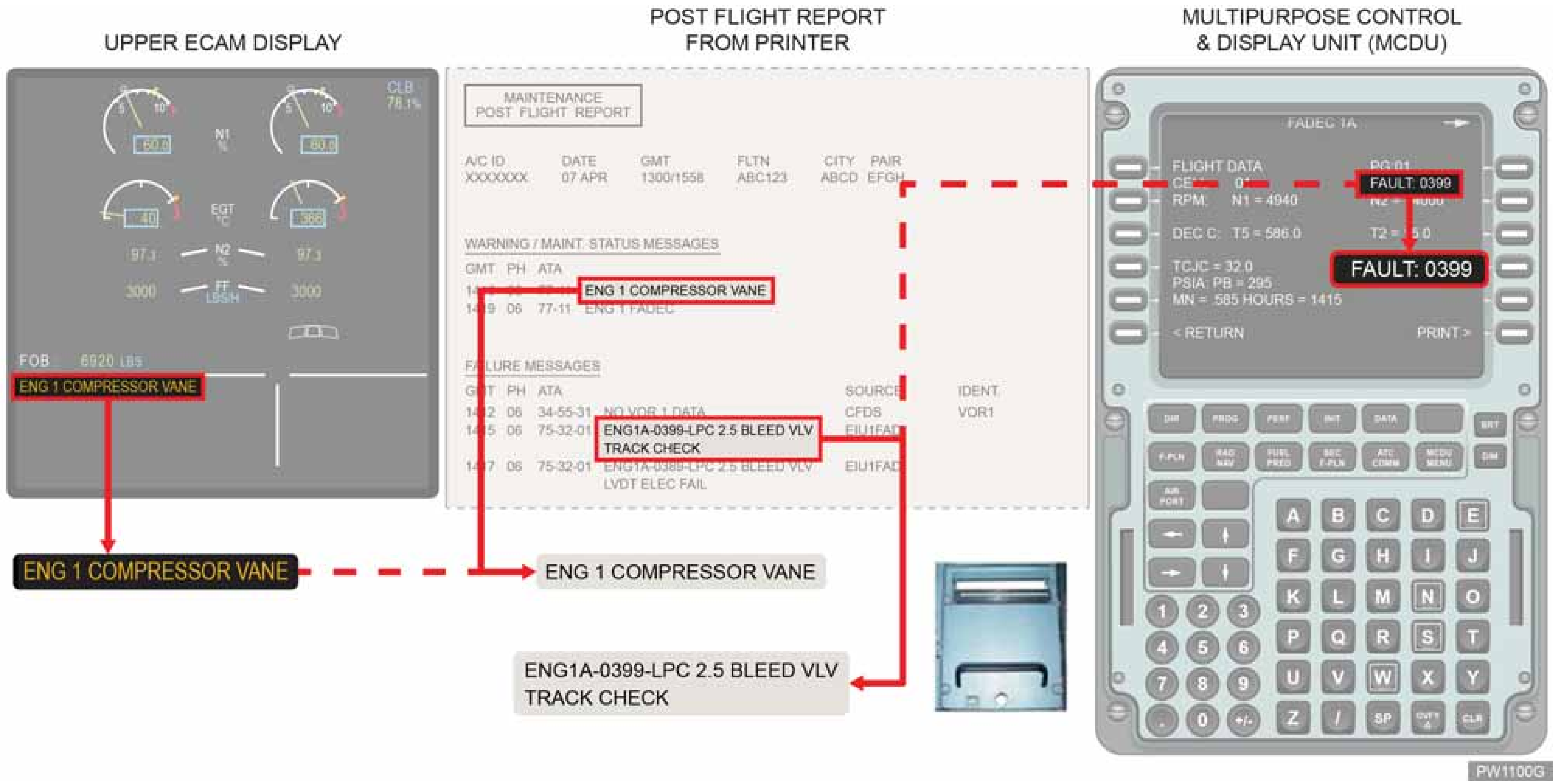
Multipurpose Control and Display Unit (MCDU)

The Multipurpose Control and Display Unit is a flight deck computer that holds various types of data communicated by the aircraft and engines.

Within the MCDU is the Centralized Fault Display System (CFDS) that holds engine data transmitted by the Full Authority Digital Electronic Control (FADEC). This data, known as the *fault code,* is key to resolving engine faults.

ECAM and PFR data are used to begin interrogation of the CFDS.

PW1100G



TROUBLESHOOTING DATA SOURCES

SOURCES FOR FAULT DATA (Cont.)

Post Flight Report (PFR)

A Post Flight Report is printed at 80 knots plus 30 seconds after touchdown, or after a ground run.

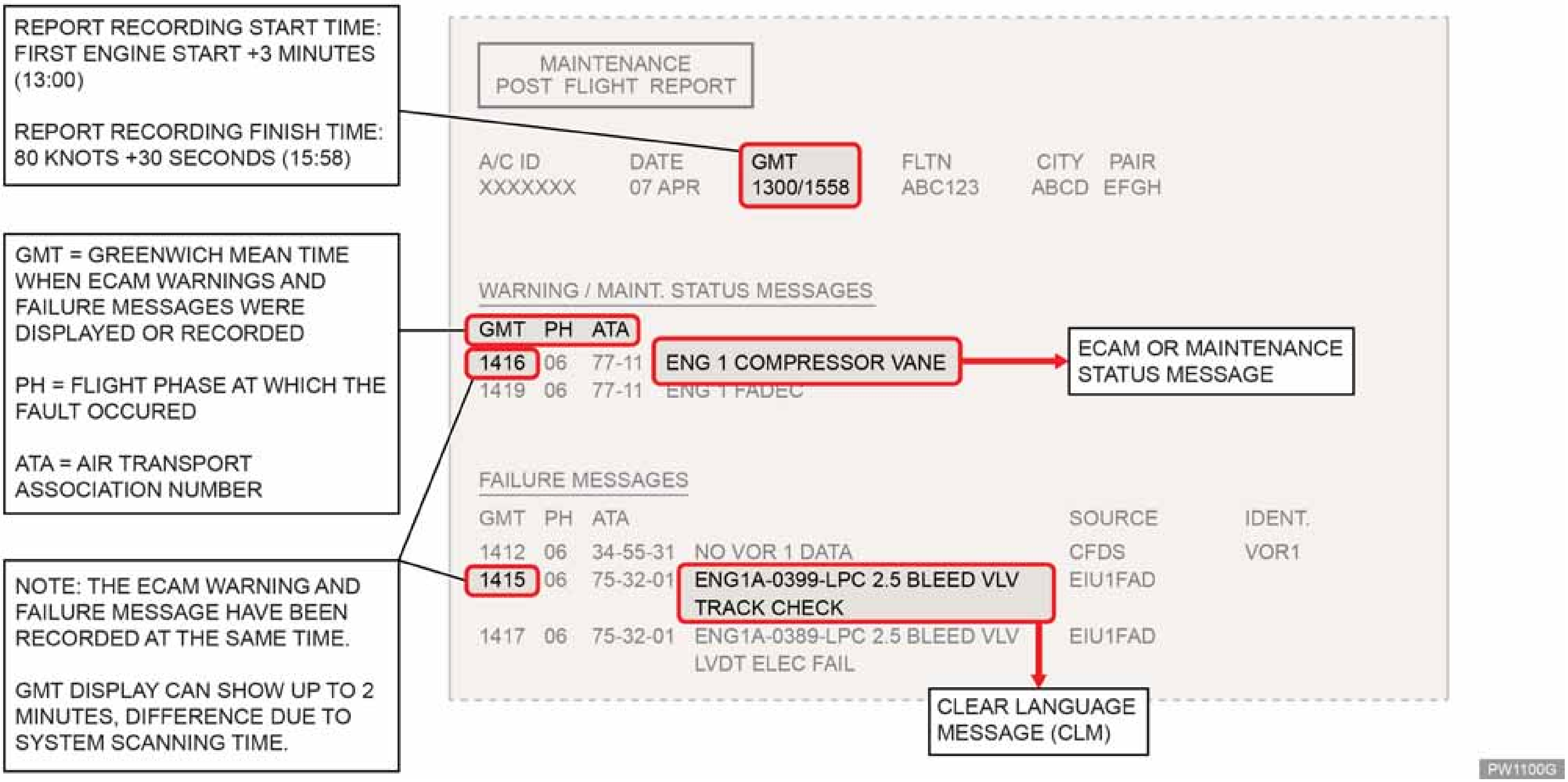
The PFR is the main source of information used to initiate troubleshooting and to decide upon required maintenance actions. It lists fault data associated with the ECAM warning and uses Clear Language Message (CLM) form to provide some of its details.

A backup of the printed PFR is available through the MCDU. The backup should only be used if the printed PFR is not available, because the information is less complete and not as easy to interpret.

The CFDIU correlates fault messages to limit the number printed on the PFR and to give maintenance staff the root cause of the fault.

PFR Display Data

- ECAM WARNING/MAINTENANCE STATUS MESSAGES contains the warning messages as displayed on the upper ECAM display unit, plus maintenance status (STS) messages. These warning messages are shown with their ATA reference**,** an aid for cross referencing with the maintenance message**.**
- FAILURE MESSAGES shows maintenance messages including Clear Language Message (CLM) given for the associated ECAM Warning, or STS messages with additional details.
- ATA shows the ATA chapter for the primary component suspected of the fault. This information is the entry point to the Troubleshooting Manual (TSM). It may also be an aid to the corresponding failure message and GMT. Note that CFDIU correlation of fault messages is based on the GMT and on the ATA chapter of the received failure messages.
- SOURCE shows the system BITE or the computer that generated the maintenance message retained by the CFDIU for this event.
- IDENTIFIERS are the computers that have reacted in relation to the fault by generating external maintenance messages not retained by the CFDIU.



POST FLIGHT REPORT (PFR) DISPLAY DATA

SOURCES FOR FAULT DATA

Post Flight Report (PFR)

PFR Display Data (Cont.)

- FLIGHT PHASE & GMT are flight operational phases (CLIMB, CRUISE, etc.) indicated in coded form on the PFR in front of the message. Together with the time (GMT), these show the stage, or phase, in which the failure occurred.

NOTE

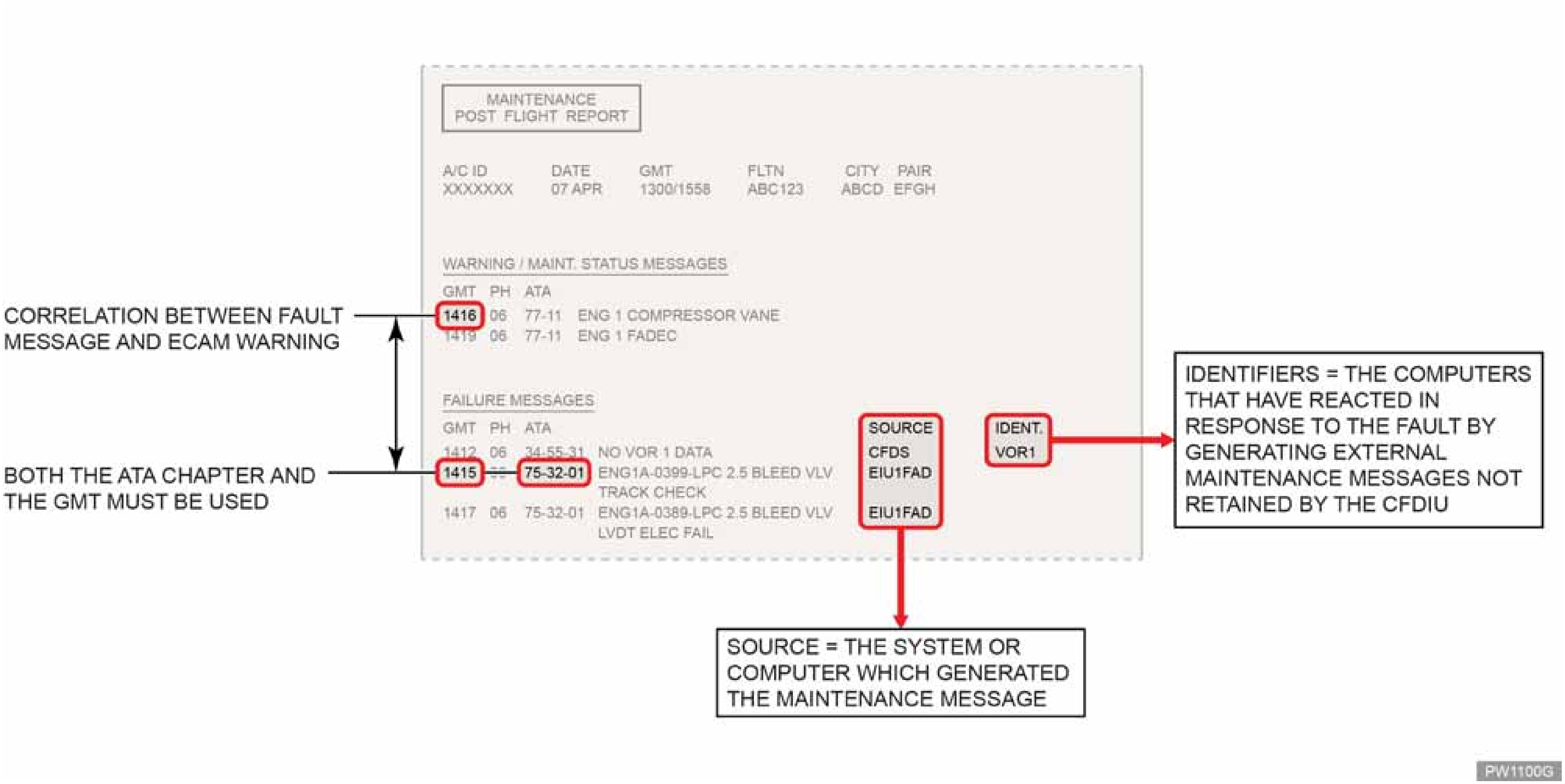
If the fault appears and disappears several times during the same flight, the corresponding fault message is transmitted only at first detection.

The ECAM warning for a Class 1 fault or the maintenance status for a Class 2 STS fault may be repeatedly displayed in the flight deck and transmitted to the CFDIU even if there is only one associated fault message.

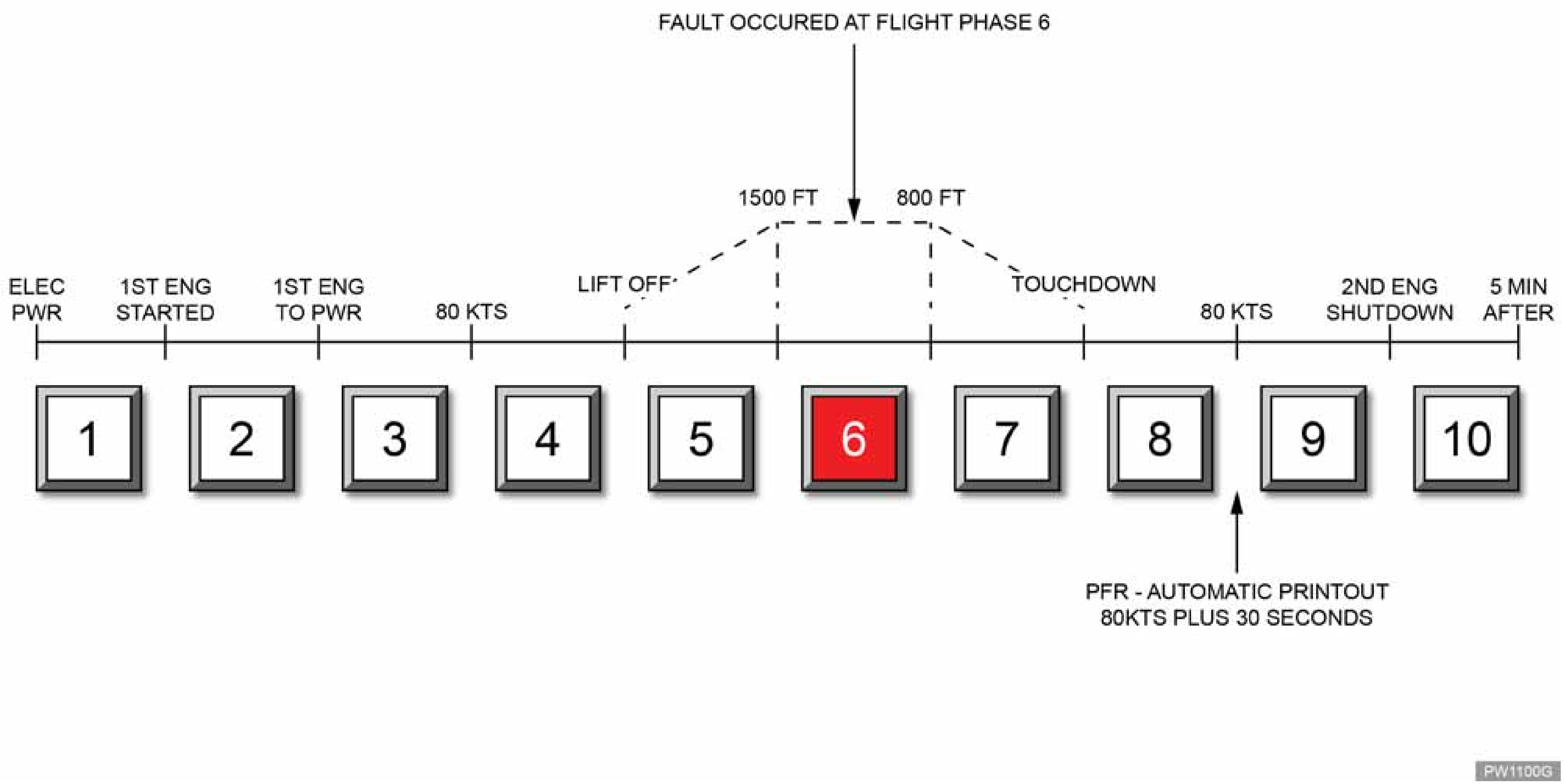
Maintenance staff must correlate information in the fault message and Class 1 ECAM warning or Class 2 maintenance status. The ATA chapter, GMT and flight phase must be used.

The flight phase appears in coded numerical form. More information on each phase is shown in the chart.

Phase	Code Meaning
01	Electrical Power ON before first engine start
02	Electrical start, plus three minutes up to Take Off/Go Around (TOGA) power
03	TOGA power up to 80 knots
04	80 knots up to liftoff
05	Climb
06	Cruise
07	Descent
08	Touchdown to 80 knots
09	80 knots to last engine shutdown
10	Second engine shutdown after flight, plus five minutes



POST FLIGHT REPORT CORRELATION OF INFORMATION



FLIGHT PHASE DECODING

SOURCES FOR FAULT DATA (Cont.)

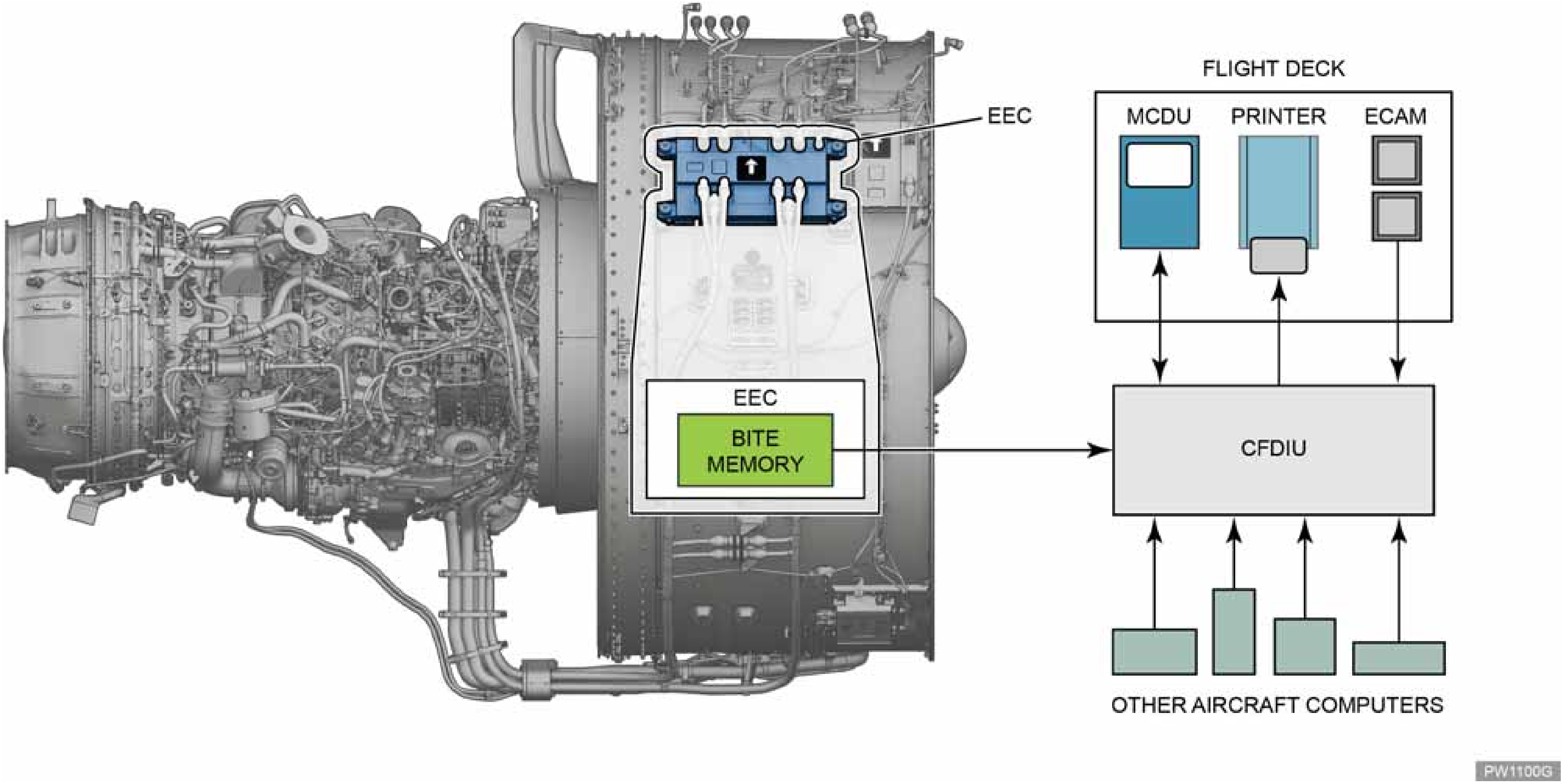
Centralized Fault Display System (CFDS)

The Centralized Fault Display System provides maintenance engineers with a central maintenance aid to interrogate at the system or sub-system level. The CFDS consists of both the Built In Test Equipment (BITE) and the Centralized Fault Display Interface Unit (CFDIU).

- The BITE continuously monitors aircraft system operation. Detection of failures, as well as processing and formatting of the failure messages to be displayed, is a function of each aircraft system's BITE.

Information from the BITE is coordinated by the Centralized Fault Display Interface Unit (CFDIU).

BITE information is interrogated using an MCDU located on the flight deck. Note that there are two MCDUs: the captain's and the first officer's. Only one must be used for interrogation at a time.



CENTRALIZED FAULT DISPLAY SYSTEM (CFDS)

SOURCES FOR FAULT DATA

Centralized Fault Display System (CFDS) (Cont.)

BITEs are provided with Flight and Ground memory zones to store any reported faults. When a failure is detected, it is stored in the BITE memory and transmitted to the CFDIU. The CFDIU will memorize these CLMs to generate the CURRENT (LAST) LEG REPORT. The BITE for each system memorizes 64 previous reports.

Reading or printing of all failure information is done in the flight deck. The Flight Warning Computer (FWC) sends the ECAM messages to the CFDIU. The CFDIU will memorize these messages to generate the CURRENT (LAST) LEG REPORT.

CFDS Modes

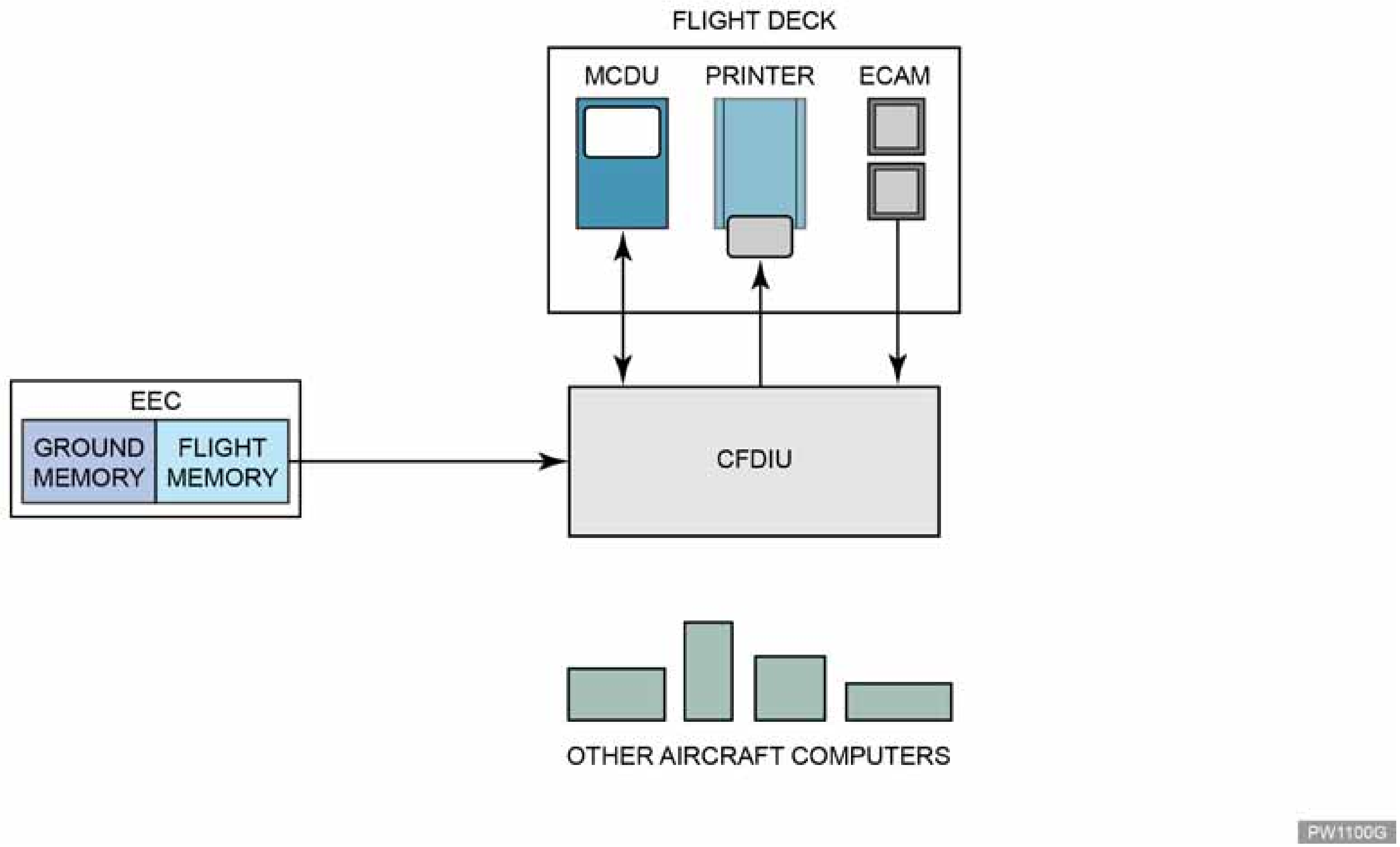
The CFDS has both Normal and Menu modes.

Normal Mode

In this mode, the CFDIU scans all the connected system outputs and memorizes the failure messages in order to generate the CURRENT (LAST) LEG REPORT and the CURRENT (LAST) LEG ECAM REPORT. In flight, the CFDS always operates in Normal Mode.

Menu Mode

In this mode, the CFDIU interfaces with one computer at a time in order to read the contents of its BITE memory and to initiate various system tests. This mode can only be selected on the ground and interrupts Normal Mode operation.



CENTRALIZED FAULT DISPLAY – BITE MEMORY ZONES

FAULT CODES

Fault codes are crucial fault information found in the CFDS and indicate the troubleshooting process to use.

Fault codes will always generate a Clear Language Message (CLM) and should always be used to identify the correct task in the Troubleshooting Manual (TSM).

ACCESSING FAULT DATA USING THE MCDU

Finding collected fault information in the Centralized Fault Display System (CFDS) requires use of the Multipurpose Control and Display Unit (MCDU). Part of the flight deck panel display, the MCDU features Line Entry keys to access information about the detected fault.

The MCDU illustration on the following page shows a typical method of accessing the CFDS for an engine fault.

The PFR and observations from the flight crew provide initial indications of the fault, leading to determination of the specific system area and the fault class, used for further investigation.

In the example below, the PFR indicated a double fault on the No. 1 engine 2.5 bleed valve, showing both a Class 1 Track Check error and Class 2 LVDT Electrical Failure. Both faults are in Channel A, but occurred at different times in the flight. The following steps demonstrate how to use the MCDU to find out more information on one of the faults.

1. Power up the FADEC and access the MCDU.

2. Enter the CFDS system by pressing the Line Entry key beside the CFDS indication on the screen.

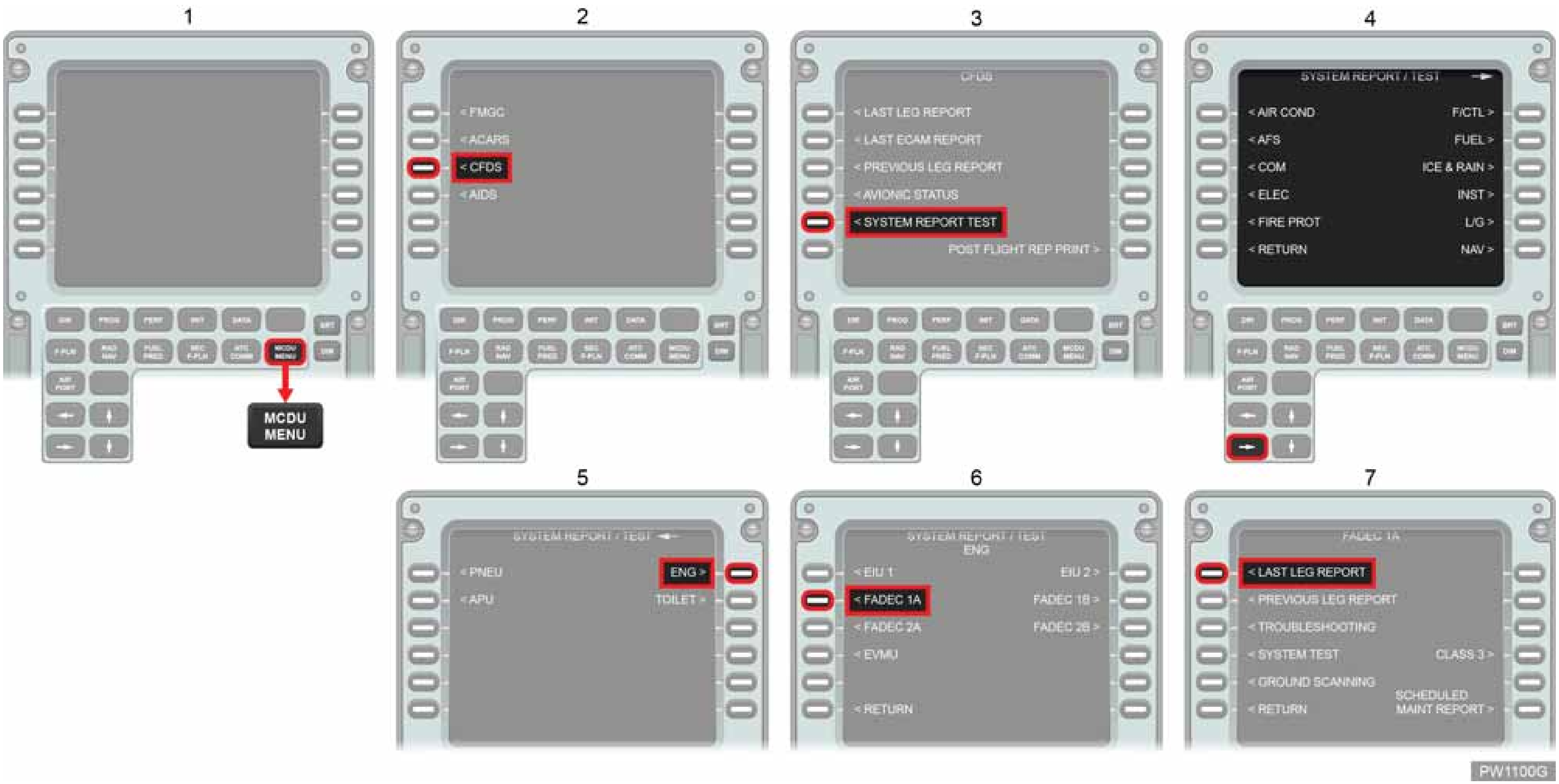
3. Select System Report Test on the CFDS page.

4. Press the NEXT PAGE key on the Function keypad.

5. Press the Line Entry Key next to the ENG indication to access logged engine faults.

6. Press the Line Entry Key next to FADEC 1A.

7. Press the Line Entry Key next to LAST LEG REPORT.



ACCESSING FAULT CODE ON THE MCDU (1 OF 2)

ACCESSING FAULT DATA USING THE MCDU

8. (Cont.)

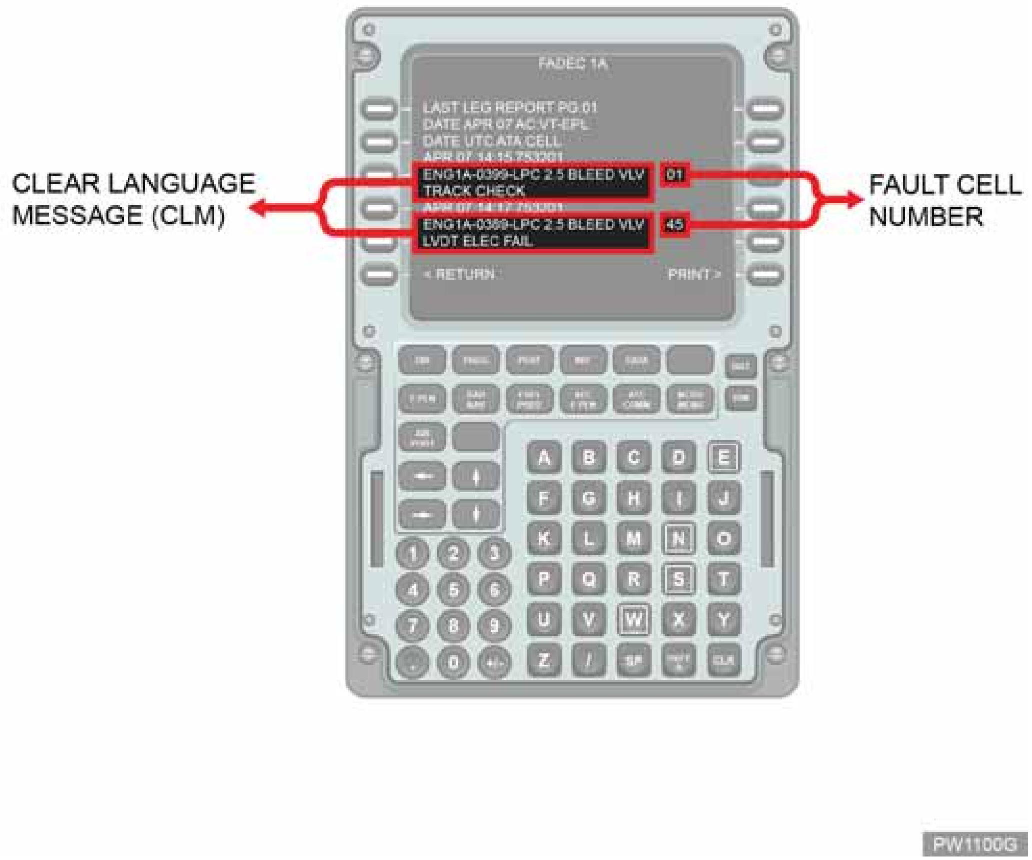
   Examine the screen, which shows the FADEC 1A – LAST LEG REPORT page. It displays the following information:

   - Clear Language Message (ENG 1A-0399-LPC 2.5 BLEED VLV TRACK CHECK)

   - ATA reference number (75 32 01)

   - date and time the fault occurred (APR 07 14:15).

   The indication is the same fault as seen on the PFR. The fault cell number, which was not shown on the PFR, is seen on this screen next to the CLM, Cell Number (01).



ACCESSING FAULT DATA USING THE MCDU (Cont.)

9. Press the Line Entry Key next to RETURN to go back one menu page for further fault interrogation.

10. This screen is now the FADEC 1A for System Report/Test. Press the Line Entry Key next to TROUBLESHOOTING to go to the Troubleshooting menu page. The FADEC 1A – TROUBLESHOOTING menu page again requires an entry to identify where the fault occurred.

    Troubleshooting data can be accessed in these locations:

    - Fault Cells 01-45 = FLIGHT DATA
    - Fault Cells 46-80 = GROUND DATA
    - Fault Cells 61-60 = Class 3

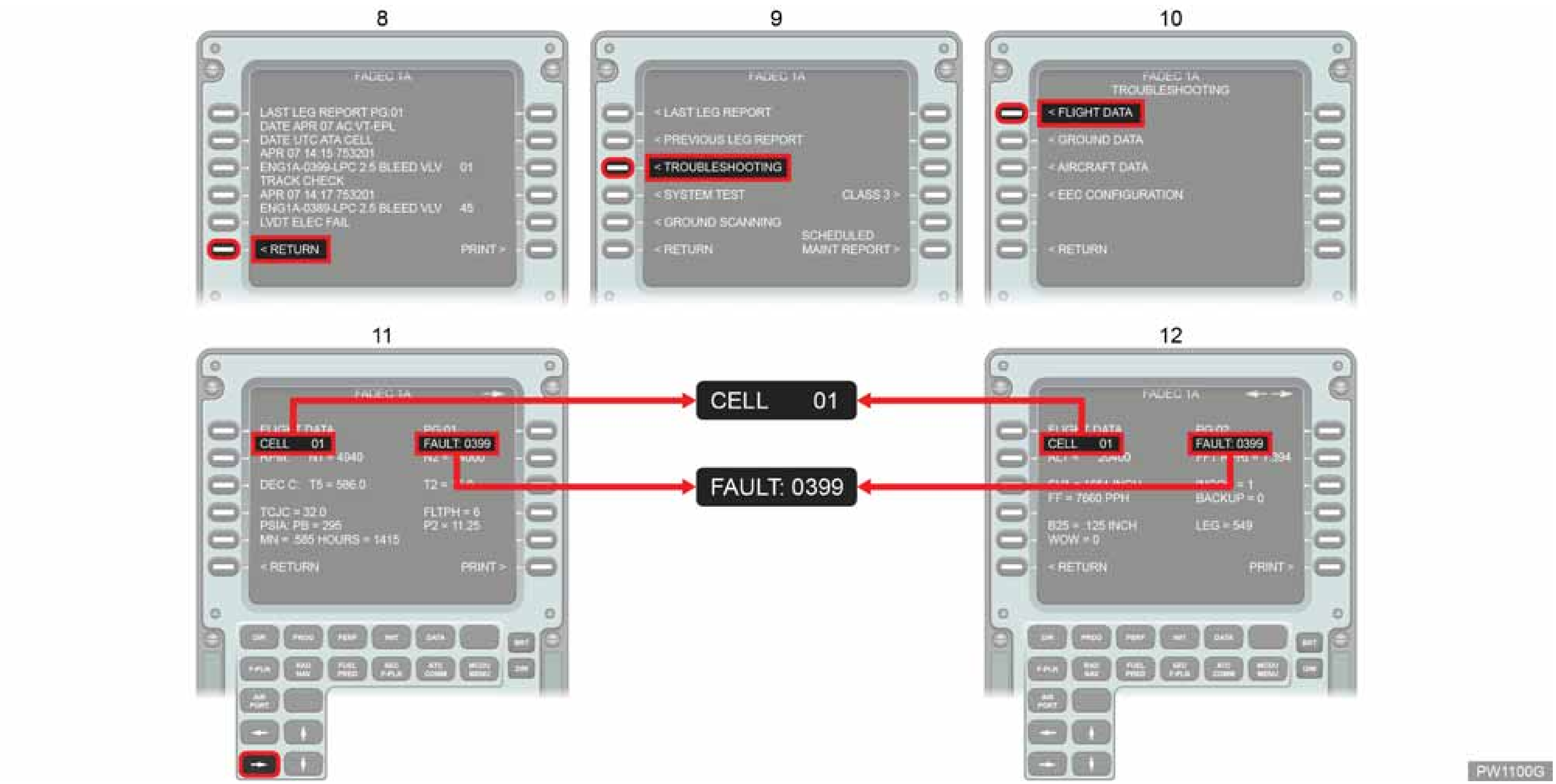
    In the example, the CLM was stored in Cell Number (01).

11. Press the Line Entry Key next to FLIGHT DATA.

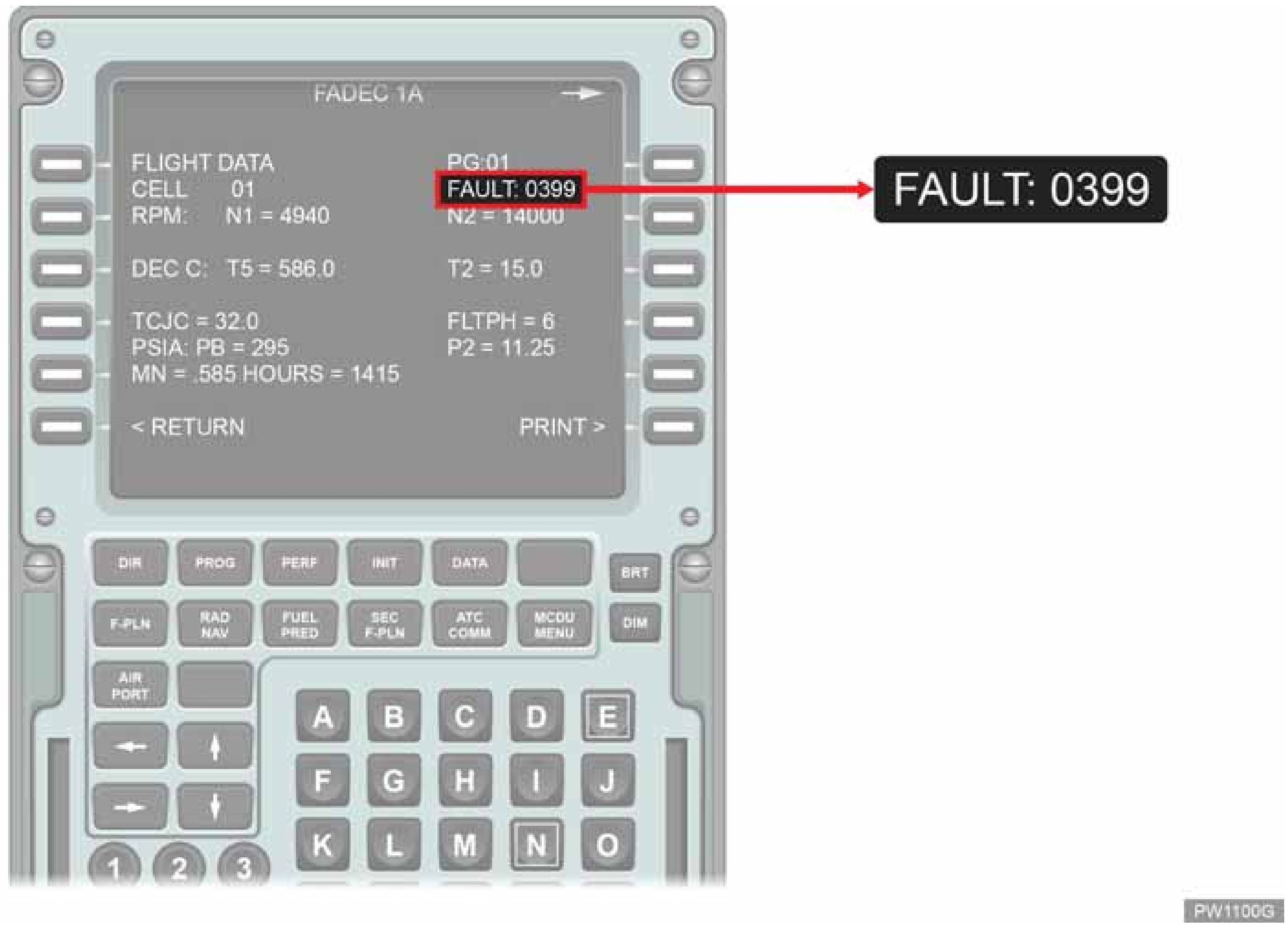
    This page shows some of the details of all engine and aircraft parameters when the fault occurred. While these details may not be useful at this time, they will assist further investigation by engineers if the fault proves to be persistent. More important for this level of fault diagnosis is the fault code given and annotated with the same Cell Number (01) as the previous level. In this case, 0399 indicates that the LPC 2.5 Bleed Valve has a track check failure. It also shows there is an additional page, as a forward arrow is given at the top right hand corner.

12. Pressing the NEXT PAGE key on the function keypad takes you to the final page.

13. More engine and aircraft parameters are provided here together with the same fault code and Cell Number details as before.



ACCESSING FAULT CODE ON THE MCDU (2 OF 2)



FAULT CODE – FLIGHT DATA SCREEN

ACCESSING FAULT DATA USING THE MCDU (Cont.)

Parameter Description

Below is a description of the additional engine information displayed when a fault occurs.

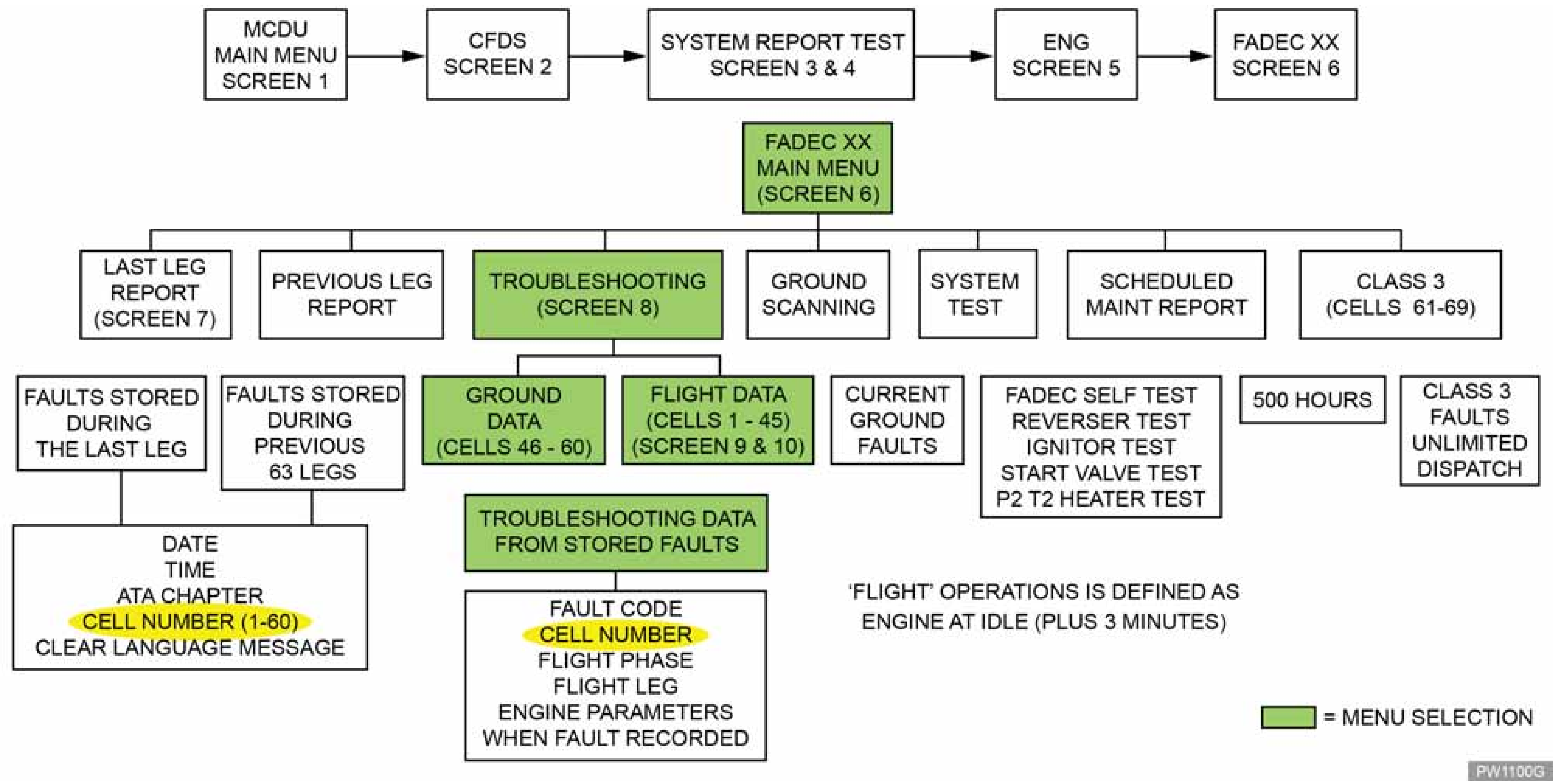
Parameter	Description	Parameter	Description
FAULT	Four-digit code	PB	HPC delivery pressure in PSIA
ALT	A/C altitude (fault recording)	FLTPH	Flight phase (fault recording)
N1/N2	RPM values	BACKUP	Channel in backup mode when fault recorded
T5	EGT values in degree C	P2	Inlet pressure in PSIA
SVA	Stator vane actuator travel in inch	B25	2.5 bleed valve ram travel in inch
T2	Inlet temperature in degree C	MN	Mach number (fault recording)
INCON	Channel in control when fault was recorded (1 = in control)	LEG	EEC total flight leg
TCJC	Thermocouple Cold Junction Compensation (CJC) temperature (internal EEC temp. in degree C)	HOURS	EEC run time
FF	Fuel flow in PPH	WOW	Weight on Wheels (1 = on ground)

PARAMETER DESCRIPTION

ACCESSING FAULT DATA USING THE MCDU (Cont.)

MCDU Flow Chart

The chart below shows the selection process route map to obtain the required fault code using the MCDU.



MCDU SCREEN ROUTE MAP

LOCATING TROUBLESHOOTING PROCEDURES

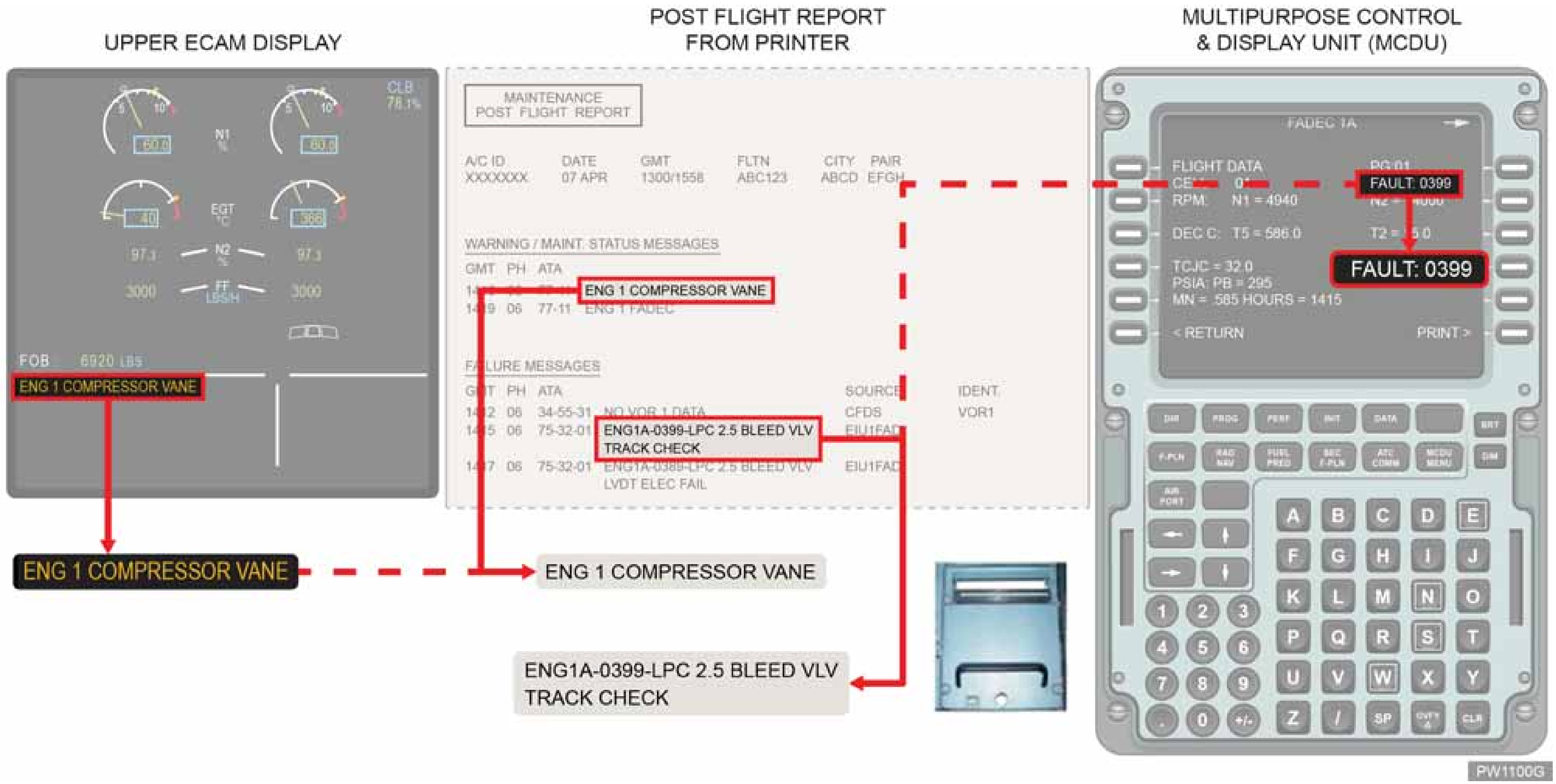
Overview

A fault reported by the flight or maintenance crew is used as an entry point into the Troubleshooting Manual (TSM). Depending on the type of fault, and using information from the various data sources, the troubleshooter is directed to the corresponding fault isolation procedure.

The data sources include the upper ECAM screen, the Post Flight Report (PFR), and the Multipurpose Control and Display Unit (MCDU). The PFR takes information from the MCDU and is also reflected on the ECAM. Examples of each are illustrated below.

Note that the first step of troubleshooting is turning on the EEC power.

PW1100G



DATA SOURCES FOR TROUBLESHOOTING

LOCATING TROUBLESHOOTING PROCEDURES

Overview (Cont.)

Use the following procedure to troubleshoot upper ECAM warnings, ECAM STS maintenance messages or CFDS fault messages.

1. Compare the ECAM warning or ECAM STS message with the CFDS failure message, if applicable, using the time code to obtain the fault symptom and the ATA chapter reference.
2. Using the troubleshooting function of airnav^X , input the fault symptom, correlate the CFDS message and retrieve the associated fault isolation procedure in the TSM. Retrieve the fault code by interrogating the CFDS through the MCDU. This takes you to the relevant fault isolation procedure steps in the TSM task.

NOTE

A time difference of one to three minutes between the fault message and the warning message may occur due to the CFDIU internal behavior.

All faults producing a flight deck effect and detected by the systems are covered by a Class 1 or 2 message and transmitted to the Centralized Fault Display Interface Unit (CFDIU).

Class 1 ECAM MAINTENANCE STATUS messages are always presented in the PFR at the end of the flight.

For further fault isolation, use the source column and/or CFDS fault message identifiers column. Due to the number of possible identifiers, the fault message identifier in the Troubleshooting Manual must be the same as on the PFR.

Correct interpretation of PFR information quickly locates the appropriate troubleshooting task for a particular system problem.

In the example below, a problem is detected with the Engine 1 Compressor Vane. This message appeared on the upper ECAM as an ECAM Warning, which is a Class 1 failure and cannot be dispatched.

The CFDS Fault Message is text contained under the heading FAILURE MESSAGES on the PFR. Again, in this example, the Failure Message that is linked to the ENG 1 COMPRESSOR VANE is: **ENG 1A-0399-LPC 2.5 BLEED VLV TRACK CHECK.**

The text along with the ATA reference number 75-32-01 and the Source, EIU1FAD, are copied into the associated text boxes in the airnav^X troubleshooting section.

MAINTENANCE
POST FLIGHT REPORT

A/C ID	DATE	GMT	FLTN	CITY PAIR
XXXXXXX	07 APR	1300/1558	ABC123	ABCD EFGH

WARNING / MAINT. STATUS MESSAGES

GMT	PH	ATA	
1416	06	77-11	ENG 1 COMPRESSOR VANE
1419	06	77-11	ENG 1 FADEC

FAILURE MESSAGES

GMT	PH	ATA		SOURCE	IDENT.
1412	06	34-55-31	NO VOR 1 DATA	CFDS	VOR1
1415	06	75-32-01	ENG1A-0399-LPC 2.5 BLEED VLV TRACK CHECK	EIU1FAD	
1417	06	75-32-01	ENG1A-0389-LPC 2.5 BLEED VLV LVDT ELEC FAIL	EIU1FAD	

PW1100G

FAULTS APPEARING ON POST FLIGHT REPORT (PFR)

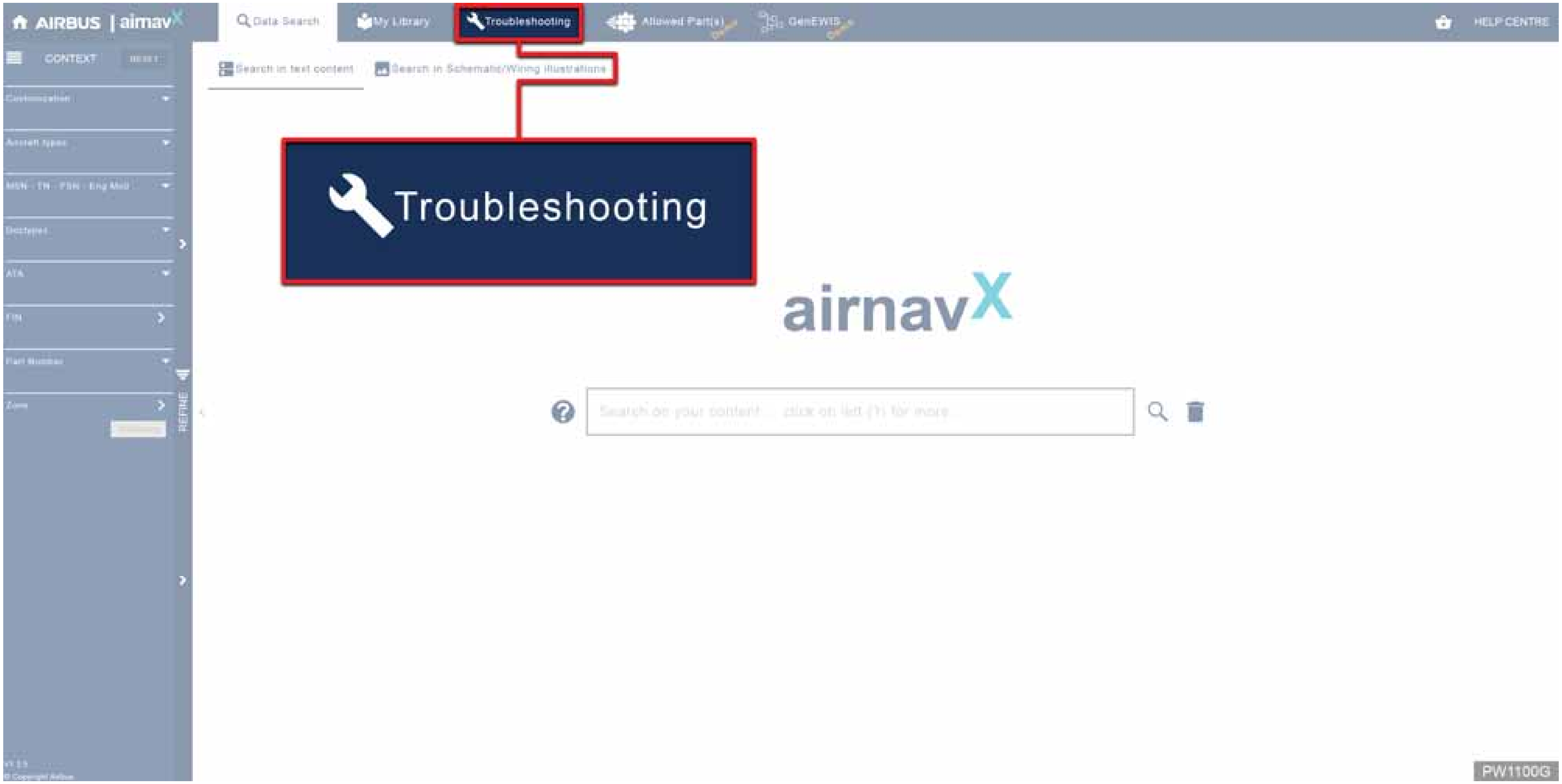
LOCATING TROUBLESHOOTING PROCEDURES (Cont.)

Using airnav^{X}

Airnav^{X} is the Airbus tool for accessing a collection of manuals. Its functions include data search, a library of technical manuals, and the Troubleshooting Manual (TSM).

The TSM uses fault codes and ECAM warnings to identify and locate troubleshooting procedures. For this reason, the TSM requires users to input a known troubleshooting task reference number when accessing the program.

Unless a procedural task has already been identified during a previous investigative activity, the TSM is not practical.



TROUBLESHOOTING MANUAL ON airnav^{X}

LOCATING TROUBLESHOOTING PROCEDURES

Using airnav^{X} (Cont.)

ECAM Warning Messages

Warning messages are indicated on the upper ECAM screen.

A Post Flight Report (PFR) displays information as shown in the graphic below.

POST FLIGHT REPORT WITH ECAM WARNING MESSAGES

LOCATING TROUBLESHOOTING PROCEDURES

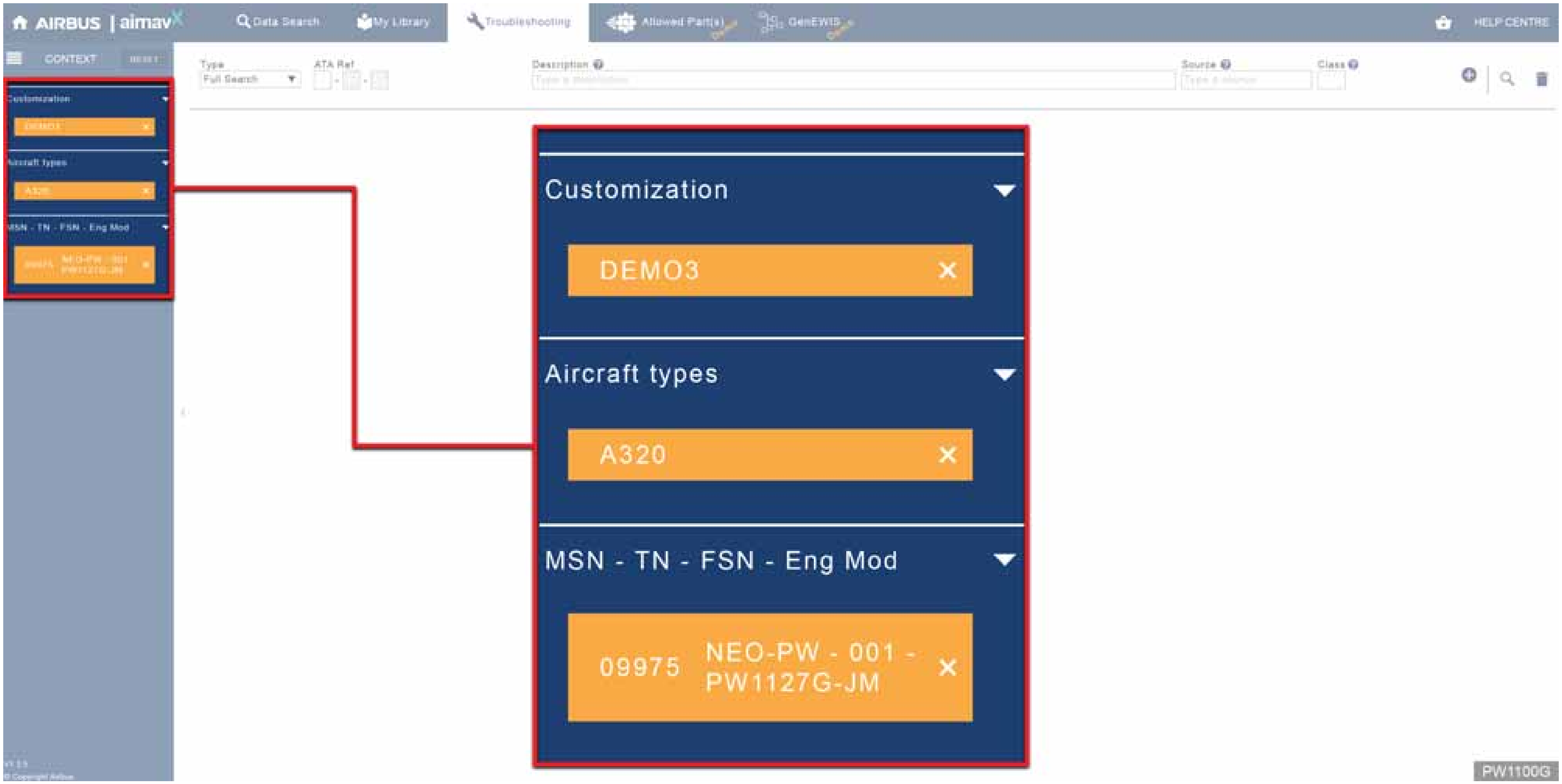
Using airnav^X (Cont.)

1. Select Troubleshooting from the main airnav^X screen. The Troubleshooting Home Page displays.

2. On the left navigation bar, select the aircraft type.

NOTE

The troubleshooting search bar only displays when an aircraft type is selected.



TROUBLESHOOTING SECTION OF airnav^{X}

LOCATING TROUBLESHOOTING PROCEDURES

Using airnav^{X} (Cont.)

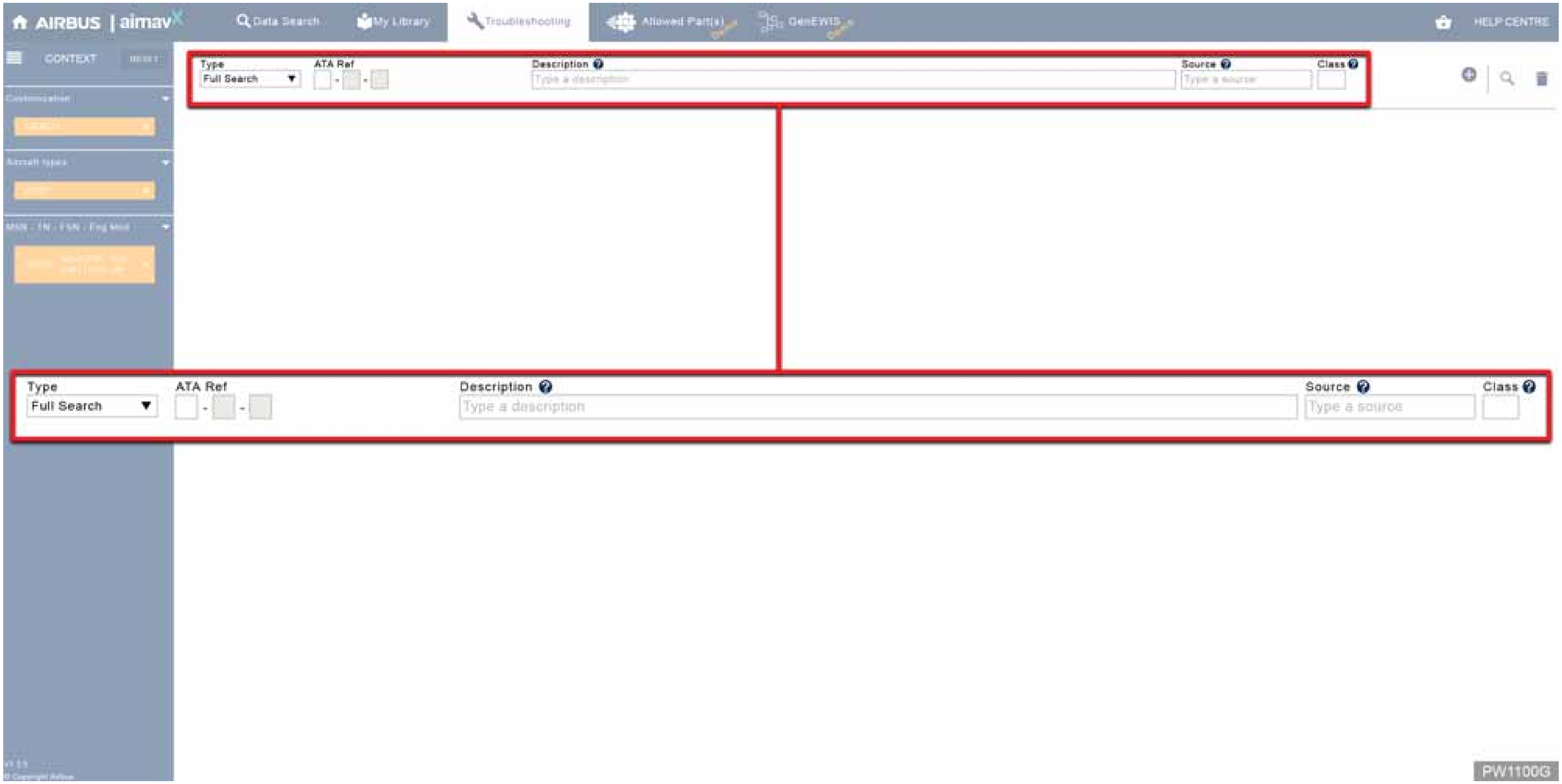
3. Enter any available information into the search bar.

NOTE

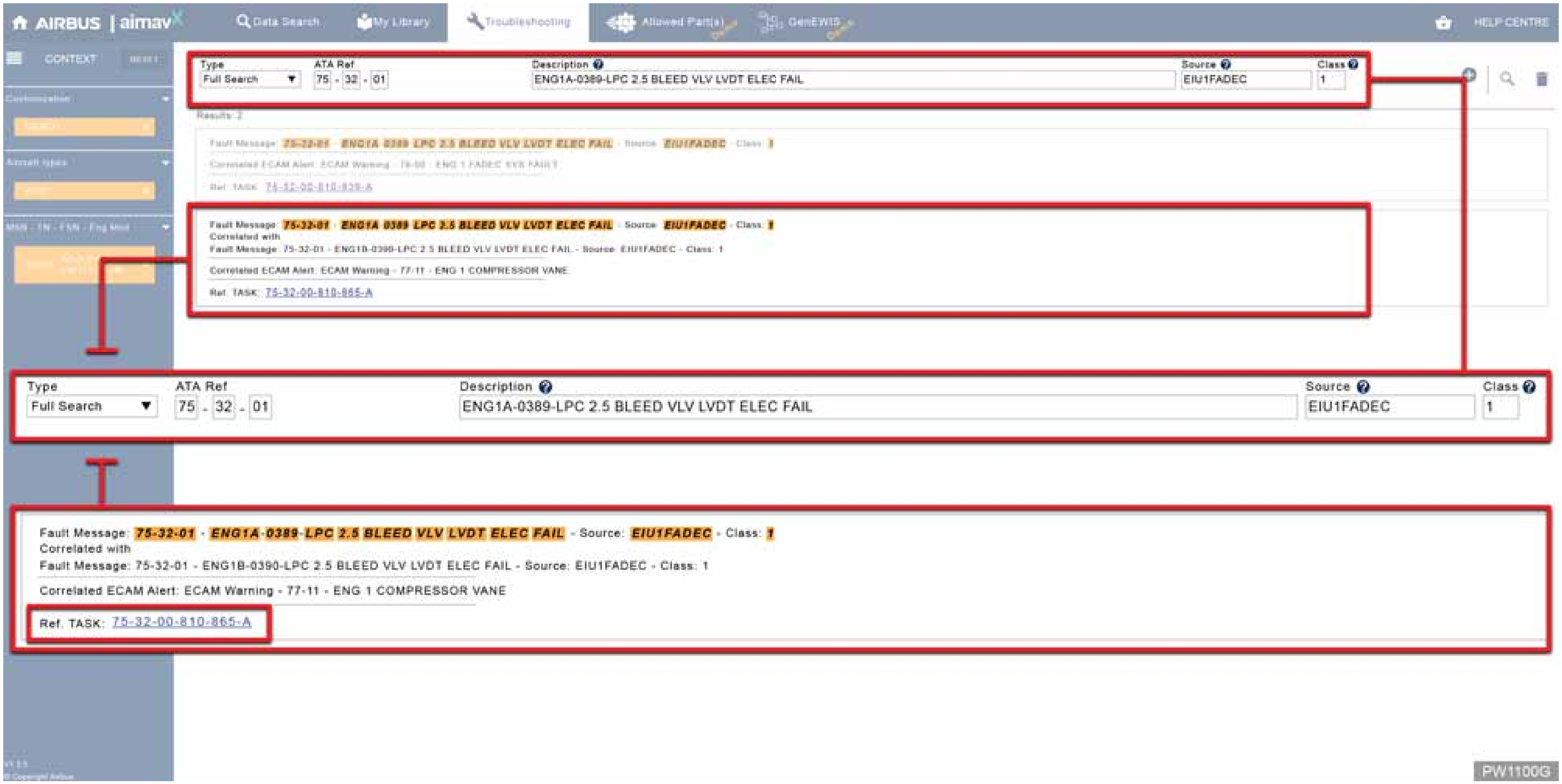
The search bar can accommodate partial or missing information.

Input fields and their meanings for the troubleshooting search bar are described in the chart.

Field	Meaning
Type	The source of the fault message. Possible sources are • ECAM Alert • Fault Message • Local Effect • Crew/Maintenance Observation • Full Search (generic search)
ATA	The ATA number displayed with the fault, if applicable
Description	Description of the fault using the fault code number or the complete Clear Language Message (CLM), if applicable
Source	The source of the fault code, as listed in the Post Flight Report, if applicable
Class	The class of the fault, if applicable



SEARCH FOR THE TROUBLESHOOTING PROCEDURE (1 OF 2)



SEARCH FOR THE TROUBLESHOOTING PROCEDURE (2 OF 2)

LOCATING TROUBLESHOOTING PROCEDURES

Using airnav^{X} (Cont.)

4. Select the appropriate TSM link to access the troubleshooting procedure.

AIRBUS | aimavX   TSM - A318,A319,A320,A321 - DEMO3 - 01-Feb-2020. MSN: 09975 - NEO-PW - FSN: 001 - Engine: PW1127G-JM   HELP CENTRE

Fault Symptoms

**** ON A/C FSN ALL**

TASK 75-32-00-810-839-A
LPC (2.5) Bleed Valve - LVDT Electrical Failure Channel A

1. Possible Causes:

2. Job Set-up Information

3. Fault Confirmation

SUBTASK 75-32-00-710-095-A

A. Do the EEC system interactive test to confirm this fault. Refer to FADEC self test Ref. AMM 73-21-00-710-806.

NOTE: The Electronic Engine Control (EEC) has detected the LVDT circuit signals from the 2.5 bleed valve actuator are out of range or rate in channel A. The 2.5 bleed valve actuator is mounted on the compressor intermediate case at the 10 o'clock position.

- Refer to the general troubleshooting guidelines for additional troubleshooting information Ref. TSM TASK 71-00-00-810-834.
- Refer to the component and harness intermittent troubleshooting procedure for guidance troubleshooting intermittent faults Ref. TSM TASK 71-00-00-810-835.

(1) If the maintenance message does not come back, examine the harnesses and electrical connectors as described in the component and harness intermittent fault isolation procedure Ref. TSM TASK 71-00-00-810-835.

(a) If no problems are found, return the engine to service. Monitor the engine for reoccurring maintenance message.

(2) If the maintenance message comes back (hard fault), go to the Para. Fault Isolation.

WARNING: BE CAREFUL WHEN YOU DO WORK ON THE ENGINE AFTER SHUTDOWN. THE ENGINE CAN STAY HOT FOR A LONG TIME. IF YOU DO NOT OBEY THIS INSTRUCTION, INJURY CAN OCCUR.

WARNING: BE CAREFUL WHEN YOU USE CONSUMABLE MATERIALS. OBEY THE MATERIAL MANUFACTURER'S INSTRUCTIONS AND YOUR LOCAL REGULATIONS.

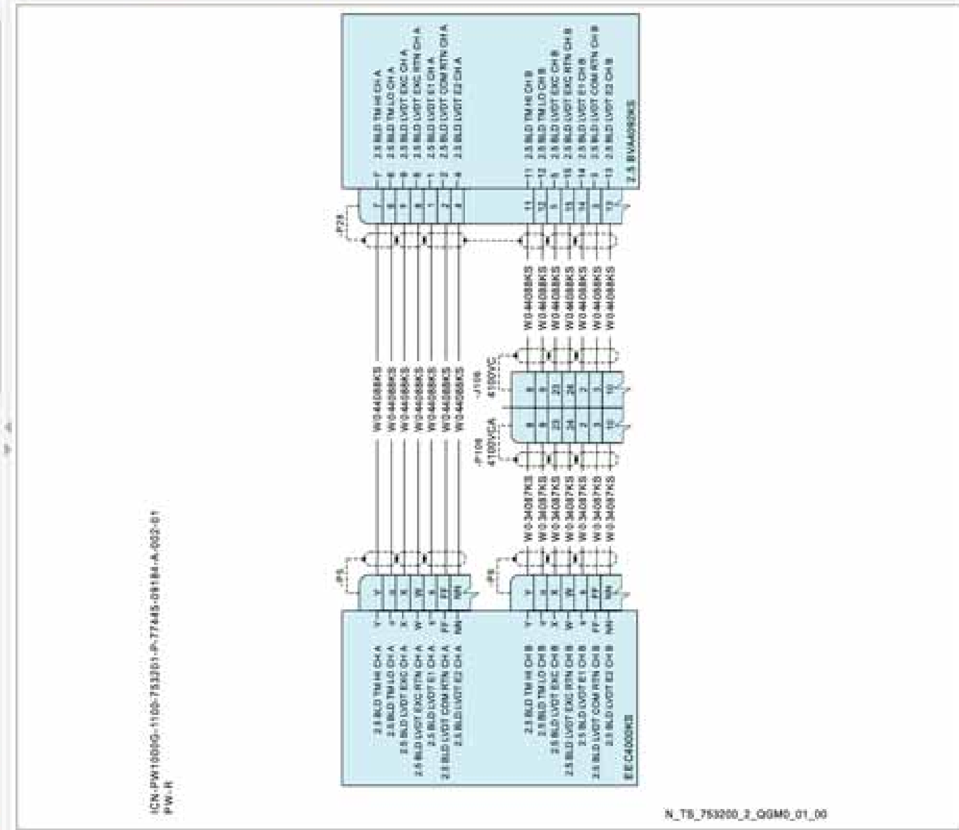


Figure 75-32-00-991-02100-21-A (SHEET 1) - 2.5 Bleed Valve Actuator Wiring Schematic
** ON A/C FSN ALL

PW1100G

ACCESS THE TROUBLESHOOTING PROCEDURE

CHAPTER 13

ABBREVIATIONS AND GLOSSARY

ABBREVIATIONS

ACC	Active Clearance Control
ACR	Aft Cascade Ring
ADIRU	Air Data Inertial Reference Unit
AGB	Angle Gearbox
AMM	Aircraft Maintenance Manual
AODV	Active Oil Damper Valve
AOHE	Air/Oil Heat Exchanger
AOPS	Auxiliary Oil Pressure Sensor
APF	Aft Pylon Fairing
APU	Auxiliary Power Unit
ATS	Air/Turbine Starter
BAHE	Buffer Air Heat Exchanger
BAM	Buffer Air Manifold
BAPS	Buffer Air Pressure Sensor
BAV	Buffer Air Valve
BFE	Buyer Furnished Equipment
BITE	Built In Test Equipment
BLS	Bifurcation Latch System
BOAS	Blade Outer Air Seals
BVA	Bleed Valve Actuator
CAA	Closure Assist Assembly
CAN	Controller Area Network
CAS	Crew Alert System
CESL	Common Engine Software Loader
CFDS	Centralized Fault Display System
CFDIU	Centralized Fault Display Interface Unit
CIC	Compressor Intermediate Case
CJC	Cold Junction Compensation
CLM	Clear Language Message
CMC	Central Maintenance Computer
CSD	Constant Speed Drive
DCV	Directional Control Valve
DOS	Door Opening System
DSP	Digital Signal Processor
DSU	Data Storage Unit
EBU	Engine Buildup Unit
ECAM	Electronic Centralized Aircraft Monitor
ECS	Environmental Control System
EDP	Engine Driven Pump
EEC	Electronic Engine Control

ABBREVIATIONS (Cont.)

EGT	Exhaust Gas Temperature
EHSV	Electro Hydraulic Servo Valve
EIU	Engine Interface Unit
FADEC	Full Authority Digital Electronic Control
FDGS	Fan Drive Gear System
FEGV	Fan Exit Guide Vane
FFD	Fuel Flow Divider
FFDP	Fuel Filter Differential Pressure sensor
FIC	Fan Intermediate Case
FMU	Fuel Metering Unit
FOHE	Fuel/Oil Heat Exchanger
FOHEBV	Fuel/Oil Heat Exchanger Bypass Valve
FPGA	Field Programmable Gate Array
FWC	Flight Warning Computer
FWS	Flight Warning System
GSE	Ground Support Equipment
HCPU	Higher-level Central Processing Unit
HCU	Hydraulic Control Unit
HOR	Hold Open Rod
HPC	High Pressure Compressor
HPSOV	High Pressure Shutoff Valve
HPT	High Pressure Turbine
IBR	Integrally Bladed Rotor
ICV	Isolation Control Valve
I.D.	Inner diameter
IDG	Integrated Drive Generator
IDGFOHE	IDG Fuel/Oil Heat Exchanger
IDGOOHE	IDG Oil/Oil Heat Exchanger
IFPC	Integrated Fuel Pump and Control
IFS	Inner Fixed Structure
IPCKV	Intermediate Pressure Check Valve
ITT	Inter-Turbine Temperature
IVB	Inner V Blade
JOSV	Journal Oil Shuttle Valve
kVA	Kilo Volt Ampere
LAP	Latch Access Panel
LH	Left Hand
LOPS	Low Oil Pressure Switch
LPC	Low Pressure Compressor
LPT	Low Pressure Turbine

ABBREVIATIONS (Cont.)

LRU	Line Replaceable Unit
LSOP	Lubrication and Scavenge Oil Pump
LVDT	Linear Variable Differential Transformer
MCDU	Multipurpose Control and Display Unit
MCTO	Max Continuous Takeoff
MDU	Manual Drive Unit
MEL	Minimum Equipment List
MGB	Main Gearbox
MOP	Mail Oil Pressure
MOT	Main Oil Temperature
MPD	Maintenance Planning Document
N1	Low Pressure Turbine rotor speed
N2	High Pressure Turbine rotor speed
Nf	Fan rotor speed
NAI	Nacelle Anti-Ice
NAI PRSOV	Nacelle Anti-Ice Pressure Regulating Shutoff Valve
NEO	New Engine Option
NVM	Non Volatile Memory
OCM	Oil Control Module
ODM	Oil Debris Monitor
O.D.	outer diameter
OFDPS	Oil Filter Differential Pressure Sensor
OLS	Oil Level Sensor
OTAD	Oil Tank Access Door
OVB	Outer V Blade
P2T2	Pressure and Temperature at Station 2
P2.5/T2.5	Pressure and Temperature at Station 2.5
Pamb	Ambient pressure
P/B	Push Button
Pb	Burner pressure
PCE	Pre-Cooler Exhaust
PEEK	Polyether Ether Keytone
PF	Pressure Fuel
PFR	Post Flight Report
PHMU	Prognostics and Health Management Unit
PMA	Permanent Magnet Alternator
PRSOV	Pressure Regulating Shutoff Valve
PS14	Pressure at Station 14
QAD	Quick Attach/Detach
QR	Quick Release

ABBREVIATIONS (Cont.)

RH	Right Hand
rpm	revolutions per minute
RTD	Resistance Temperature Detector
RTT	Return-To-Tank valve
SAV	Starter Air Valve
SMR	Scheduled Maintenance Report
SN	Serial Number
SVA	Stator Vane Actuator
T2	Temperature at Station 2
T3	Temperature at Station 3
T5	Temperature at Station 5
Tamb	Ambient temperature
TAI	Thermal Anti-Ice
TCA	Turbine Cooling Air
TCM	Thrust Control Malfunction
TEC	Turbine Exhaust Case
TMS	Thermal Management System
TSM	Troubleshooting Manual
Tf	Fuel Temperature
Ti	Inner T-flange
TIC	Turbine Intermediate Case
TL	Tertiary Lock
TLV	Track Lock Valve
To	Outer T-flange
TRAS	Thrust Reverser Actuation System
V AC	Voltage Alternating Current
V DC	Voltage Direct Current
VIB	Vibration
VIGV	Variable Inlet Guide Vane
VORV	Variable Oil Reduction Valve
VSV	Variable Stator Vane
WC	Wiring for core harness
WF	Wiring for fan case harness
WN	Wiring for nacelle

GLOSSARY

Axial flow: stream of air parallel to the longitudinal axis of a jet aircraft.

Ball bearing: component that holds rotating parts in axial and radial alignment, and also absorbs thrust or angular loading.

Bypass ratio: ratio of fan duct airflow to core engine stream airflow. Modern, commercial turbofan engines have a *high bypass ratio*, meaning that a comparatively large amount of air flows around the core.

Carbon seal: rotating air seal that employs a carbon ring riding against a metal mating surface to achieve a seal.

Dry motor: turns the engine with the fuel supply off.

Firtree [as in *rotor disk firtree*]: attachment featuring broached, serrated edges that joins a tapered turbine blade to the disk.

Gaspath: primary path of airflow through the engine.

Flex limits: maximum flex values between the end points when light finger pressure of approximately two pounds (8.9 n) is applied at the mid-span of safety cable.

Geared turbofan: engine technology that places a gear system between the compressor and the fan, decoupling the two. The arrangement allows components to operate more efficiently at separate, optimal speeds.

Nacelle: “skin” that protects the engine, providing an aerodynamic and protective enclosure for engine-mounted components.

Negative G: the condition in which vector acceleration downward is faster than the rate of natural freefall, resulting in a feeling of weightlessness; in this case, potentially affecting the ability of components to operate normally.

Roller bearing: holds rotating parts in radial alignment.

Spline: a mating feature for two rotating elements.

Tapered bearing: component that functions the same as a ball bearing, but requires less physical space.

Wet motor: turns the engine with the fuel supply on.

Windmill start: a method to restart an engine that has experienced a flameout. Air is forced into the engine housing to spin the rotors and create enough pneumatic pressure for ignition. Compression of at least 300 knots (560 mph) is typically required.

APPENDIX

SHOP MAINTENANCE TASKS

ATA 73

LRU MAINTENANCE TASK NUMBERS

Shop maintenance tasks for LRUs included in this course are listed in the table with their Aircraft Maintenance Manual (AMM) numbers. Note that LRUs must be located, removed, and installed according to AMM procedures. Use of special equipment must be observed and WARNINGS and CAUTIONS must be identified.

See the tasks and their associated AMM numbers below.

Maintenance Task		AMM No.
Air/Oil Heat Exchanger	AOHE	79-21-11
Inlet cone		72-11-01
Fan blade		72-11-03
Integrated Fuel Pump and Control	IFPC	73-11-01
Fuel pump filter element		73-11-06
Permanent Magnet Alternator and N2 speed transducer	PMA	73-21-04

Maintenance Task		AMM No.
Burner pressure sensor		73-21-23
N1 speed transducer		77-11-21
Nf speed transducer		77-11-22
N2 speed transducer		77-11-23
Oil filter element		79-21-06
Main Oil Temperature sensor	MOT	79-32-21
Main Oil Pressure sensor	MOP	79-33-21
Starter		80-11-01

LRU MAINTENANCE TASKS